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EFFECTIVENESS OF 7S GLOBULIN AGAINST *BOTRYTIS CINEREA* CAUSING GRAY MOLD IN STRAWBERRY

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SUMMARY

Gray mold caused by *Botrytis cinerea* is the most harmful postharvest disease responsible for the degradation of strawberries. The presented study targeted the preparation of 7S globulin from pea seeds to serve as an antifungal agent against *B. cinerea* in vitro and on the post-harvest strawberry to extend the fruits' shelf life. The 7S globulin isolation from pea seeds and characterization employed various methods, such as SDS-PAGE, FTIR, and pH solubility curve. The molecular technique also helped confirm the identity of the causative microorganism of the gray mold disease in strawberries. Utilizing rRNA gene sequencing identified a fungal pathogen that causes gray mold as *B. cinerea*. The 7S globulin showed three protein bands corresponding to α/ (83 KDa), α (68 KDa), and β (60 KDa) subunits. The isoelectric point was notable at pH 5.8. The essential and non-essential amino acids occurred around 24.92% and 54.04%, respectively. The 7S globulin inhibited the mycelial growth of *B. cinerea* in a concentration-dependent manner. The Scanning Electron Microscope (SEM) of *B. cinerea* subjected to 7S globulin showed swelling of both the fungal hyphae and conidia, significantly affected by the pea 7S-globulin treatment, entirely destabilizing and deforming their shape at 0.4 g/L. The 7S-globulin exposure maintained the fruit quality and stopped the strawberry's natural deterioration. Results further authenticated that 7S globulin (isolated from pea seeds) revealed effective antifungal action against *B. cinerea* mycelial development via a membrane-targeted mechanism. The 7S globulin affects hyphal morphology, compromises plasma membrane integrity, and prevents post-harvest gray mold on strawberry fruits.

Keywords: Strawberry (*Fragaria* × *ananassa* Duch.), *Botrytis cinerea,* gray mold disease, pea 7S globulin, antifungal activities, in vitro*,* strawberry degradation

Key findings: The pea 7S globulin inhibited the mycelial growth of *B. cinerea* in a concentration-dependent manner. The SEM of *B. cinerea* subjected to 7S globulin showed the swelling of both the fungal hyphae and conidia attaining significant effects from the pea 7S-globulin treatment, entirely destabilizing and deforming their shape at 0.4 g/L. The 7S-globulin exposure maintained fruit quality and stopped the strawberry's natural deterioration.

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INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) fruits are the most popular berries because of their supreme and unmatched flavor and numerous phytochemical contents (Oszmiański and Wojdyło*,* 2009). Strawberry fruits are highly responsive to postharvest storage because of their high average respiration and physical features (Kahramanoğlu *et al.,* 2022). The strawberry is a soft fruit crop with the highest productivity among the small berry crops.

Globally, strawberry cultivation has an area of more than 400,000 ha with a production of around 9.118 million t (Yan *et al.,* 2021). Gray mold, caused by *B. cinerea*, is one of the most significant postharvest ailments that affect strawberries and raspberries (García *et al.,* 1996). On strawberries, synthetic fungicides mainly control the gray mold, such as, cyprodinil, phenylpyrrole, anilinopyrimidine, and fludioxonil; however, an approach for the management of postharvest infection still needs to be created (Vanti *et al.,* 2021).

The fungicide application still vastly controls postharvest diseases and inhibits their related rots in various fruit crops. However, the enhanced awareness of food safety and human health has decreed accurate regulatory policies on their use (Liu *et al.,* 2013). Additionally, due to the long-term use of fungicides, new physiological races of pathogens resist various synthetic chemicals, which necessitates the prospects of natural antifungal agents (Spotts and Cervantes, 1986).

The glycoprotein used to prevent preharvest and postharvest diseases of various fruits is an alternative to synthetic fungicides (Abbas *et al.,* 2020; Atallah *et al.,* 2021; Suirta *et al*., 2021). Glycoproteins, such as, 7S globulin isolated from soybean seeds, previously exhibited as an antifungal agent in vitro and in situ for controlling the development of the green mold growing on postharvest orange fruits (Osman *et al.,* 2016a). The 7S globulin isolated from chickpea seeds also fought against *Alternaria tenuissima* isolated from fig fruit in vitro and postharvest figs, extending the fruit shelf life by reducing the disease severity by about 73% (Abbas *et al.,* 2020).

Categorizing the seed storage proteins of legumes included two types: first is the 11S globulin, and second is the 7S globulin. The protein components of soybean and other legumes suggest similar applications and functions as natural antifungal agents (Sitohy *et al.,* 2012; Osman *et al.,* 2014; Abdel-Shafi *et al.,* 2019a). The main objective of the pertinent study was to prepare the 7S globulin from pea seeds and use it as an antifungal agent against *B. cinerea* in vitro and on the postharvest strawberry to extend its fruit shelf life.

MATERIALS AND METHODS

Characterization of 7s globulin from pea seeds

Pea seeds (*Pisum sativum* L.) obtained from a local market in Zagazig City, Sharkia Governorate, Egypt, underwent dehulling and grinding into flour using a laboratory mill. The flour defattening with n-hexane happened overnight. The solvent evaporation used a rotary evaporator, with the defatted dried meal kept in closed plastic containers at 4 °C until further analysis. The 7S globulin isolation from the defatted dried flour engaged an ammonium sulfate (55%–80%) precipitation procedure, as described by Abdel-Shafi *et al.* (2019a). The sodium dodecyl-sulfate polyacrylamide gel electrophoresis (SDS-PAGE) of 7S globulin isolated from pea seeds proceeded according to Laemmli (1970), as also described by Sitohy *et al.* (2013b). In the 7S globulin, the carbohydrate content estimation employed the phenol-sulfuric acid protocol through the dehydration of carbohydrates into furfural

derivatives and reacting them with phenol and sulfuric acid to develop a correlated color measurable at 490 nm (Dubois *et al.,* 1956).

Using protein pH solubility curves at several pHs from two to 10 estimated the isoelectric point of 7S globulin, according to the protocol by Sitohy and Osman (2010). The estimation of the amino acid composition of 7S globulin isolated from pea seeds was according to Simpson *et al.* (1976) using an amino acid analyzer instrument model "Eppendorf LC3000" (Abdel-Shafi *et a*l., 2016). Fourier transform infrared (FTIR) of 7S globulin estimates used the potassium bromide (KBr) pellet method (Souillac *et al.,* 2002). Acquiring the infrared spectra measurement employed the FT-IR spectrometer (Nicolet Nexus 470, DTGS, Thermo Scientific, Waltham, MS, USA) at 25 °C (Abdel-Shafi *et al.*, 2019a).

Molecular identification of the causal organism

The strawberry fruits came from a private farm in Ismailia City, Ismailia Governorate, Egypt, then the fungus isolated from those fruits with water agar (WA) medium gained incubating at 25 °C for five days. Placing onto potato dextrose agar (PDA) in Petri dishes (9 cm in diameter), the fungus attained incubation at 25 °C for 7–10 days. The 18S rRNA (Ribonucleic acid) sequencing technique helped identify the fungal isolates on a molecular level. The use of universal primers, 18SF149:5'-GGAAGGG(G/A) TGTAT TATTAG 3' and 18SR 701: 5'- GTAAAAGTCCTGGTTCCC-3', amplified a partial fragment (522 bp) of the 18SrRNA from yeast isolate PCR. The PCR mixture contained 25 pmol of each primer, 10 ng of chromosomal DNA, 200 mM dNTPs, and 2.5 U of Taq polymerase in 50 µl of polymerase buffer. The PCR thermocycler (Eppendorf) was programmed as follows: 95 °C for 5 min for initial denaturation, 30 cycles 95 °C for 1 min, 55 °C for 1 min, and 72 °C for 2 min, with a final extension at 72 °C for 10 min. Five microliters of the obtained PCR product proceeded analysis on 1% agarose gel electrophoresis (Jirage *et al.,* 1999), followed by visualization on a UV transilluminator. The PCR product purified used the QIA quick PCR purification reagent (Qiagen). The amplified 18SrRNA fragment (552 bp) received sequencing in both directions. Running the BLAST (www.ncbi.nlm.nih.gov/blast) sequence analysis helped to affiliate the yeast isolates. Multiple sequence alignment and molecular phylogeny performed ran the BioEdit (Hall, 1999).

Antifungal activity against *B. cinerea*

Testing the effect of 7S globulin (isolated from pea seeds) at different concentrations (0, 0.1, 0.2, 0.3, and 0.4 g/L) ensued on the linear growth and growth inhibition of *B. cinerea* compared with the control using the poisoned food technique (Yahyazadeh *et al.,* 2009). Plates incubation ran at 25 °C in an incubator. Colony diameters measured daily continued until control Petri dishes' complete covering with the fungal growth. Linear growth calculation had the following equation:

$$\text{Growth inhibition (\%)} = \frac{(X - Y)}{X} \text{ x } 100$$

Where:
X = Control growth
Y = Treatment growth

Scanning Electron Microscopy (SEM)

Scanning electron microscopy (SEM) estimation of *B. cinerea* treated with 7S globulin at 400 µg/ml compared with the control (without treatment) for 4 h at room temperature was according to Sitohy *et al.* (2013a).

In situ postharvest experiments

Strawberry fruits

The strawberry fruit from a local market in Zagazig City, Egypt, was brought to the plant pathology laboratory in a polystyrene box under ambient temperature and humidity to preclude mechanical damage.

In situ *antifungal activity*

Visual selection of strawberry fruits based on consistent shape, size, color, firmness, and absence of mechanical damage and fungal infection transpired to evaluate the postharvest changes. Disinfecting selected strawberry fruits used sodium hypochlorite at 1% for 1 min; then, cleaning the fruits with sterile distilled water three times continued, with the fruits dried on sanitized drying papers for 20–25 min. The use of *B. cinerea*, already isolated from the infected strawberry fruit and maintained on PDA at 4 °C, kept producing fresh cultures on PDA plates before inoculating the fresh strawberry fruit (four groups of 10 fruits each, in three replicates).

Wounding each fruit (1 mm wide and deep) used a sterile pipette tip (10 µL). Twenty microliters of 7S-globulin solutions (100, 200, and 400 µg/mL) and sterilized distilled water pipetted into each wound ensued in the strawberry fruit. Finally, injecting a conidial suspension of *B. cinerea* isolates (10 µL) at a 1.0×10^6 conidia/mL proceeded into each wound. After jabbing, fruit sealing in polyethylene-lined 5–1 plastic boxes transpired, incubating at 25 °C for 10 days. The same procedure progressed to the positive control (PC) but used distilled water instead of 7S globulin. Likewise, the negative control (NC) received the same treatment, except the fruit was neither infected with the fungus nor treated with 7S globulin. Observing and recording the form and diameter of any lesions occurred after five and 10 days of inoculation to calculate the disease incidence.

$$\textbf{Disease incidence } (\%) = (\mathbf{A}/\mathbf{B})\ \mathbf{x\ 100}$$

Where:
A: number of strawberry fruits with lesions
B: total number of strawberry-treated fruits

Disease severity determination according to the area of the lesion on each strawberry fruit used the following formula:

$$\textbf{Disease severity } (\%) = (\mathbf{I}/\mathbf{T})\ \mathbf{x\ 100}$$

Where:
I: infected tissue area
T: total tissue area

Fruit quality analysis

In addition to the disease severity and incidence, measuring weight loss (%), the fruits' pH, anthocyanin content, firmness, total soluble solids, and citric acid content continued regularly throughout 10 days with a five-day interval. Weights of treated and untreated strawberries' calculation engaged an analytical balance with an accuracy of 0.001 g at zero, five, and 10 days of storage, with 10 strawberries utilized for each condition. Expressing results went on as a weight loss percentage compared with the weight of the fruit sample on zero days.

$$\text{Weight loss } (\%) = \frac{(\text{Weight of fruit sample at 0 time} - \text{Weight of fruit sample at examination time})}{\text{Weight of fruit sample at 0 day}} \text{x100}$$

Utilizing a handheld refractometer (Atago, Tokyo, Japan) measured the juice's total soluble solids (TSS) at 20 °C. A pH meter (pH 211 Hanna Instruments Inc. Nusfalau, Romania) helped determine the pH of each fruit juice. A puncture test performed on strawberry fruits used a penetrometer machine to investigate the firmness of a strawberry fruit.

Strawberry anthocyanin contents

Detecting the strawberry anthocyanin contents (mg/100g fresh weight) followed the pH differential method (Kırca *et al*., 2007). Measuring titratable acidity (TA), expressed as g of citric acid 100 g^{-1} (fresh weight), had 10 g of the pulp titrated from each treatment added with 10 mL of H_2O with 0.1 mol L^{-1} NaOH.

Statistical analysis

The experimental layout was a completely randomized design with a factorial arrangement and three replications. Analysis of variance (ANOVA) performed for a completely randomized design ran on all data (Compton, 1994). Tukey's range test ($P \leq 0.05$)

determined the differences among cultivars, concentrations, and their interactions.

RESULTS

Characterization of 7S globulin

The SDS-PAGE electrophoretic pattern of 7S globulin (isolated from pea seeds) protrudes in Figure 1A. The 7S globulin comprises three subunits: α′ (83 KDa), α (68 KDa), and β (60 KDa). The estimated isoelectric point came from the protein pH-solubility curve, recorded at pH 5.8 (data not shown). The carbohydrate content of 7S-globulin was estimated and calculated as 5.8% (data not shown).

The 7S-globulin secondary structures' assessment used the Fourier transform infrared (FTIR) method, with the spectra shown in Figure 1B. The amide I band analysis' (1700–1600 cm^{-1}) frequent usage determined the protein's secondary structure. Amide I band peaks represented the most formidable absorption bands of the polypeptides ν(C = O). Some in-plane NH bending also contributed to amide I. The secondary structure of 7S-globulin proteins had markings by the following bands: 1610~1640 cm^{-1} for the β-sheet, 1640~1650 cm^{-1} for the random coil, 1650~1658 cm^{-1} for the α-helix, and 1660~1700 cm^{-1}. The amino acid composition of 7S globulin isolated from pea had estimates, presenting the data in Table 1. The essential and non-essential amino acids were around 24.92% and 54.04%, respectively.

Molecular identification of the causal organism

The phylogenetic tree of 18S sequences of *B. cinerea* isolated from strawberry fruit appears in Figure 2. The nucleotide sequences of the isolate were identical to those of *B. cinerea*, according to phylogenetic analyses conducted using the Maximum Likelihood Technique (Mega7) and BLAST searches conducted through NCBI (http://www.ncbi.nlm.nih.gov). The sequence submitted to GenBank had the following accession number: OK509854. Inferring the evolutionary history used the UPGMA method. The optimal tree with the sum of branch length = 0.02888307 is available. The tree drawn to a scale has branch lengths (next to the branches) in the same units as the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances computation employed the Maximum Composite Likelihood method and was in units of the number of base substitutions per site. The analysis involved 10 nucleotide sequences. Codon positions included were 1^{st} + 2^{nd} + 3^{rd} + Noncoding. A total of 502 spots remained in the final dataset, eliminating the positions containing gaps and missing data conducting evolutionary analyses in MEGA7.

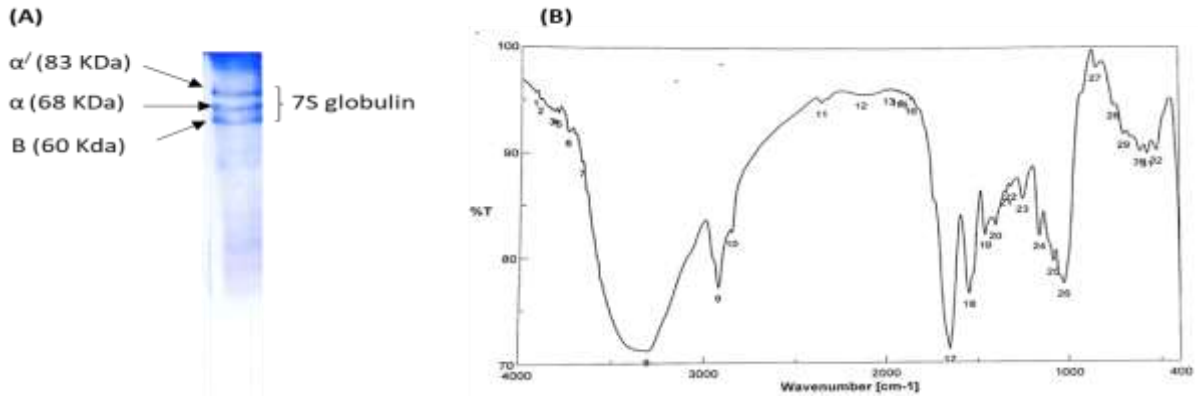

Figure 1. SDS-PAGE (A) and Fourier transform infrared **(**FTIR) spectra (B) of 7S globulin isolated from pea seeds.

Table 1. Amino acids composition of 7S globulin isolated from pea seeds.

Amino acids	Concentration (%)
Methionine	0.35
Isoleucine*	4.2
Leucine*	6.55
Valine*	2.9
Phenylalanine*	4.37
Threonine	1.35
Lysine	5.2
Arginine	6.35
Histidine	2.6
Total essential amino acids	33.87
Aspartic acid	8.65
Glutamic acid	17.87
Serine	4.65
Glycine	2.37
Alanine*	2.55
Cysteine	1.8
Tyrosine	1.85
Proline*	5.35
Total non-essential amino acids	45.09
Total amino acids	78.96

*Hydrophobic amino acids

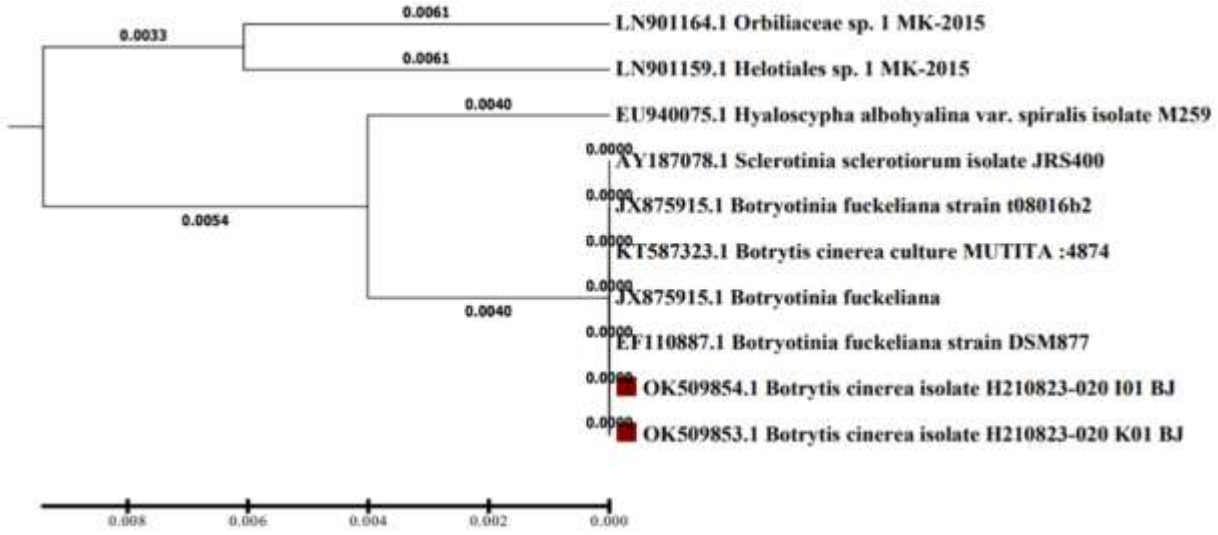

Figure 2. Phylogenetic tree of 18S sequences of *B. cinerea* isolated from infected strawberry fruits.

In vitro antifungal activity

Antifungal activity on mycelial growth

Figure 3 describes the visible fungal growth of *B. cinerea* on solid agar medium Petri dishes after seven days of incubation at 25 °C with pea 7S globulin at 0, 0.1, 0.2, 0.3, and 0.4 g/L. The 7S globulin inhibited the mycelial growth of *B. cinerea* in a concentration-dependent manner. The *B. cinerea* fungal growth lessened by 15%, 26%, 35%, and 41%, respectively, responding to 7S globulin at 0.1, 0.2, 0.3, and 0.4 g/L.

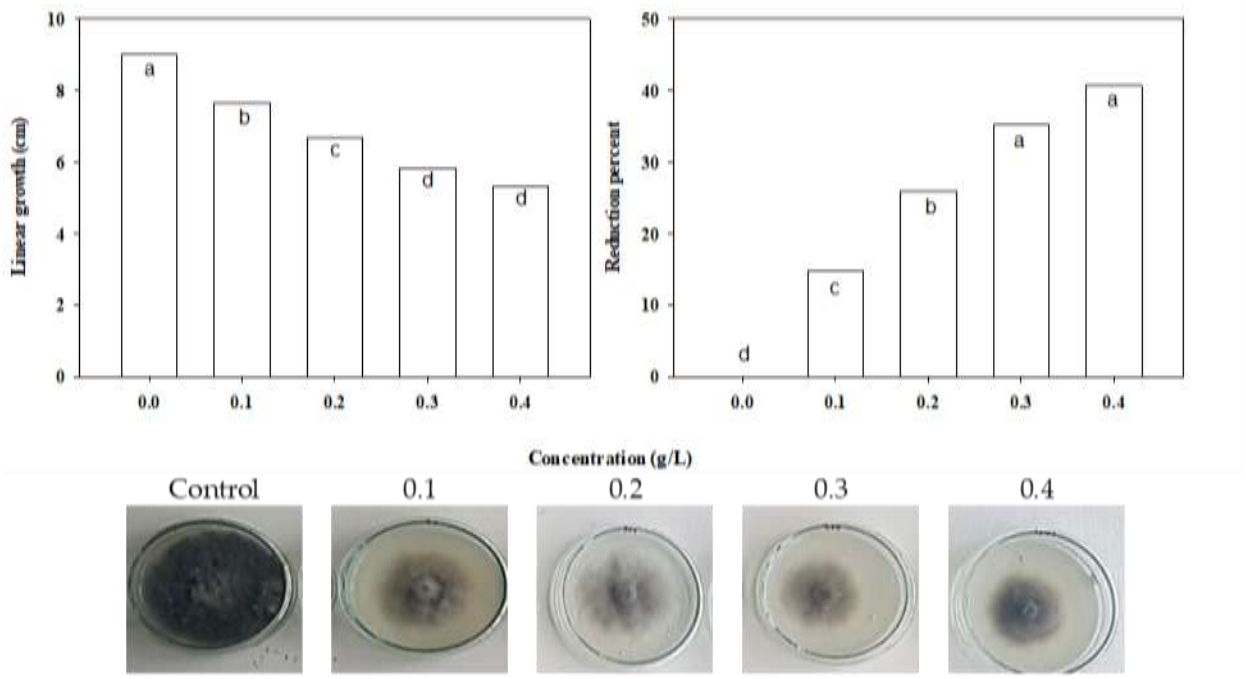

Figure 3. Effect of different concentrations of 7S globulin compared with the control against inhibition of *B. cinerea* mycelial growth.

Scanning Electron Microscopy (SEM)

After being treated with pea 7S globulin (0.4 g/L) for 4 h at room temperature, the SEM images of *B. cinerea* emerge in Figure 4. The untreated fungus revealed typical hyphae with walls that seemed to be unbroken. The causal agent *B. cinerea* typical untreated fungal conidia SEM image exhibited quite a regular, pear-shaped morphology at both magnification settings (5000× and 10000×). The anatomical characteristics of fungal hyphae and conidia have acquired significant effects from the pea 7S-globulin treatment that entirely destabilized and deformed their shape at 0.4 g/L.

In situ antifungal activity

***7S-globulin effect on strawberry inoculated with* B. cinerea**

The exposure of strawberry fruits inoculated with *B. cinerea* to 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) reduced disease incidence (Figure 5A). After five days of inoculation and exposure to 7S globulin, the disease incidence was 37%, 23%, and 18% for 0.1, 0.2, and 0.4 g/L, respectively. After 10 days with the inoculant, 7S-globulin treatments significantly decreased the disease incidence by 85%, 80%, and 73% for 0.1, 0.2, and 0.4 g/L, respectively, compared with the control. The three 7S-globulin concentrations tend to reduce the disease severity (Figure 5B). After five days of injection and exposure to 7S globulin, the disease severity was 47%, 40%, and 33% for 0.1, 0.2, and 0.4 g/L, respectively. After 10 days of inoculation, 7S-globulin treatments decreased the disease severity by 52%, 45%, and 40% for 0.1, 0.2, and 0.4 g/L, respectively, compared with the control.

***7S-globulin effect on strawberry fruits quality inoculated with* B. cinerea**

The effects of 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) on firmness (N) in strawberry fruits injected with *B. cinerea* are available in Figure 6A. Compared with the control, the strawberry fruit preserved with 7S globulin at various

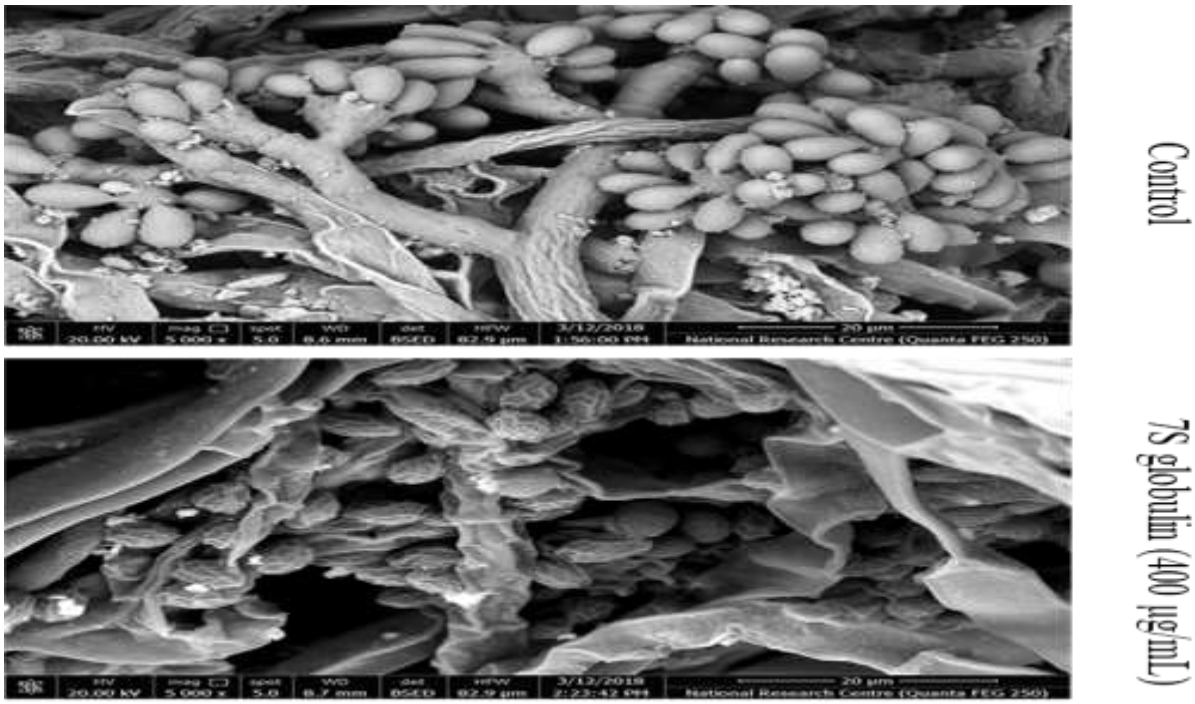

Figure 4. Scanning electron microscopy (SEM) showing the effects of pea 7S globulin (0.4 g/L) on *B. cinerea* compared with the control (untreated sample).

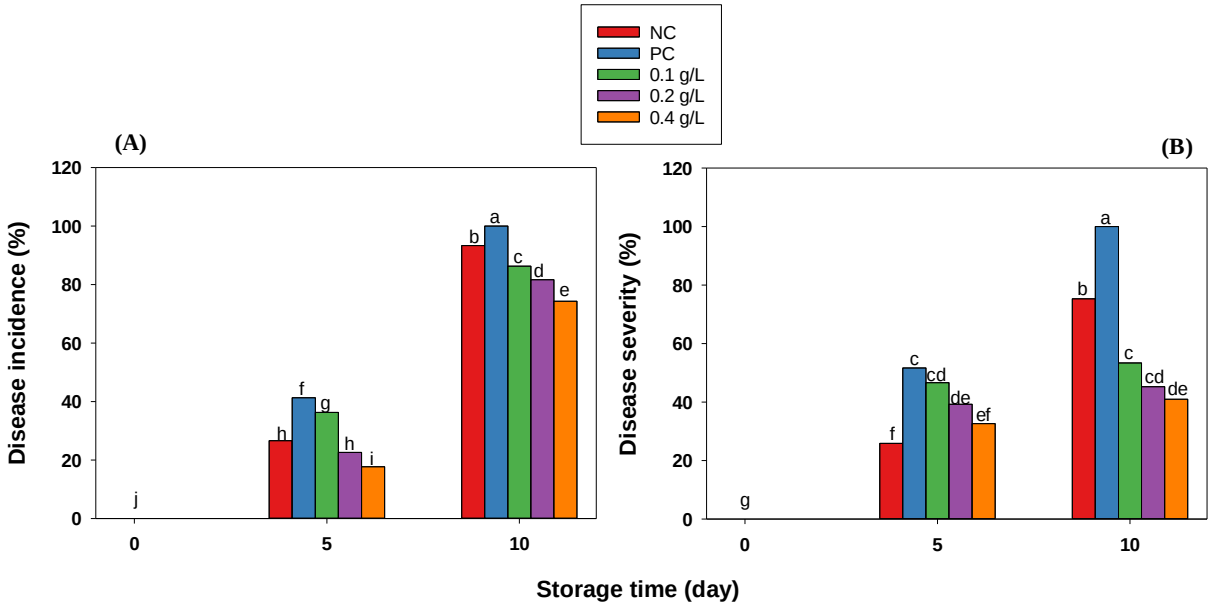

Figure 5. Effect of 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) on gray mold incidence (A) and disease severity (B) of strawberry fruits artificially inoculated with *B. cinerea* (10 µL of 1×10^6 conidia/mL) compared with negative and positive controls (NC and PC, respectively). Means followed different letters significantly differ according to Tukey's HSD test ($P \leq 0.05$).

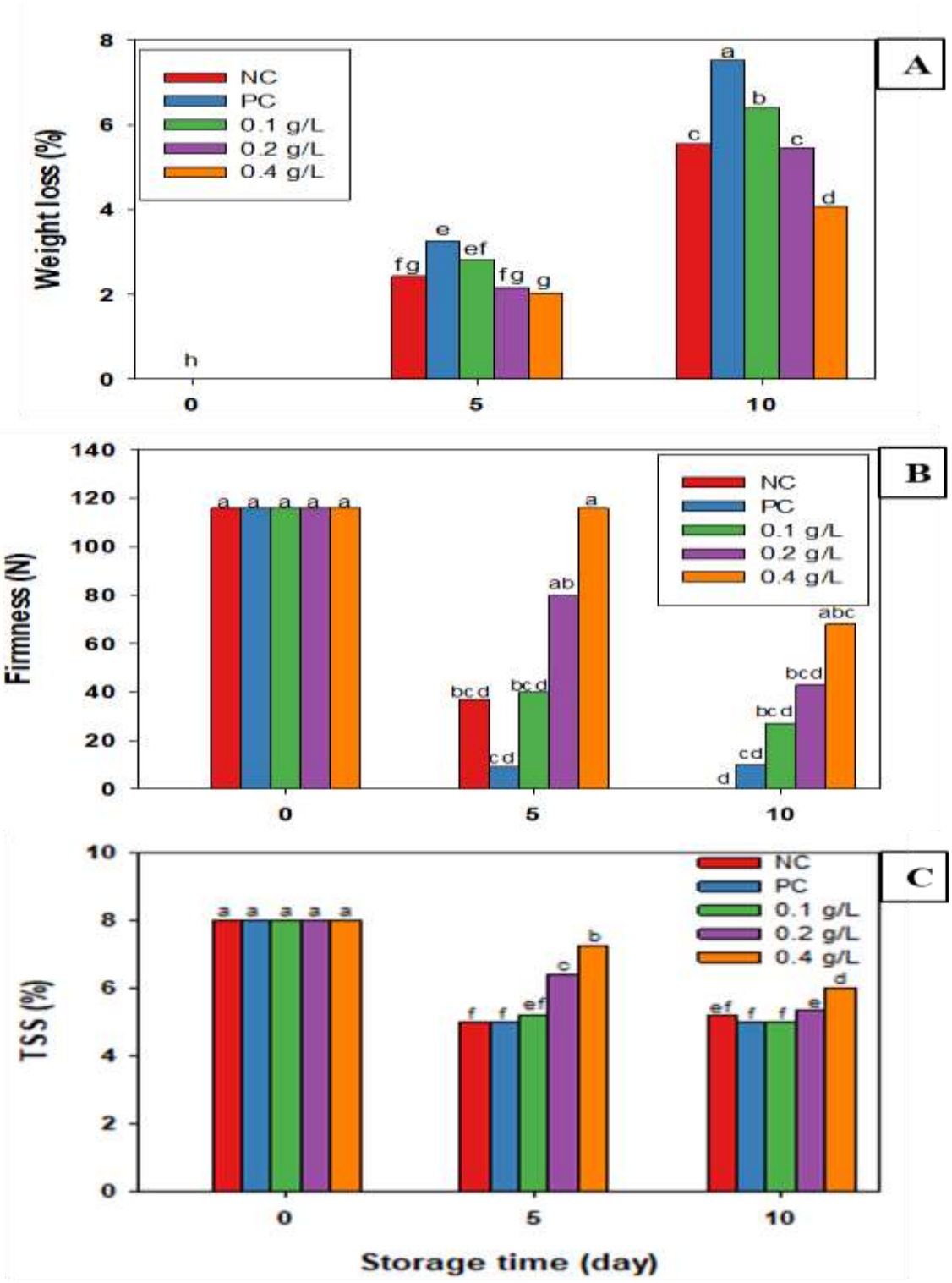

Figure 6. Effect of 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) on weight loss (A), firmness (B), and total soluble solids (C) in strawberry fruits inoculated with *B. cinerea* compared with negative and positive controls (NC and PC, respectively). Means followed different letters significantly differ according to Tukey's HSD test ($P \leq 0.05$).

concentrations lost less weight. Weight loss rates were significantly lower across all the treatments than the control. After 10 days of storage, the fruit treated with 7S globulin (0.4 g/L) lost 4% weight versus 8% weight loss in the positive control. The impact of 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) on firmness (N) in strawberry fruits inoculated with *B. cinerea* appears in Figure 6B. After five days of storage, the preserved strawberry fruits with 7S globulin (0.2 and 0.4 g/L) were the most efficient treatments in maintaining firmness (80 N and 116 N) compared with the positive control (8 N).

After 10 days of storage, the preserved strawberry fruits with 7S globulin at 0.4 g/L (68 N) have significantly ($P < 0.05$) higher firmness than the positive control (10 N). The impact of 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) on total soluble solids (TSS%) in strawberry fruits inoculated with *B. cinerea* is visible in Figure 6C. After five days of storage, the preserved strawberry fruits with 7S globulin (0.2 and 0.4 g/L) were the most efficient treatments in maintaining TSS (6.4% and 7.23%) compared with the positive control (5%). After 10 days of storage, the preserved strawberry fruits with 7S globulin at 0.2 and 0.4 g/L (5.37% and 6%, respectively) has significantly ($P < 0.05$) higher TSS versus the positive control (5%). The effects of 7S globulin at 0.1, 0.2, and 0.4 g/L on anthocyanin content in strawberry fruits inoculated with *B. cinerea* occur in Figure 7. Strawberry fruit's total anthocyanin content gained influences from both 7S globulin and preservation time. After five days of storage, the results displayed that anthocyanin was considerably ($P < 0.05$) lower in the positive control (154 mg/100 g FW) than in the 0.4 g/L treated group (169 mg/100 g FW). After 10 days of storage, the same results happened.

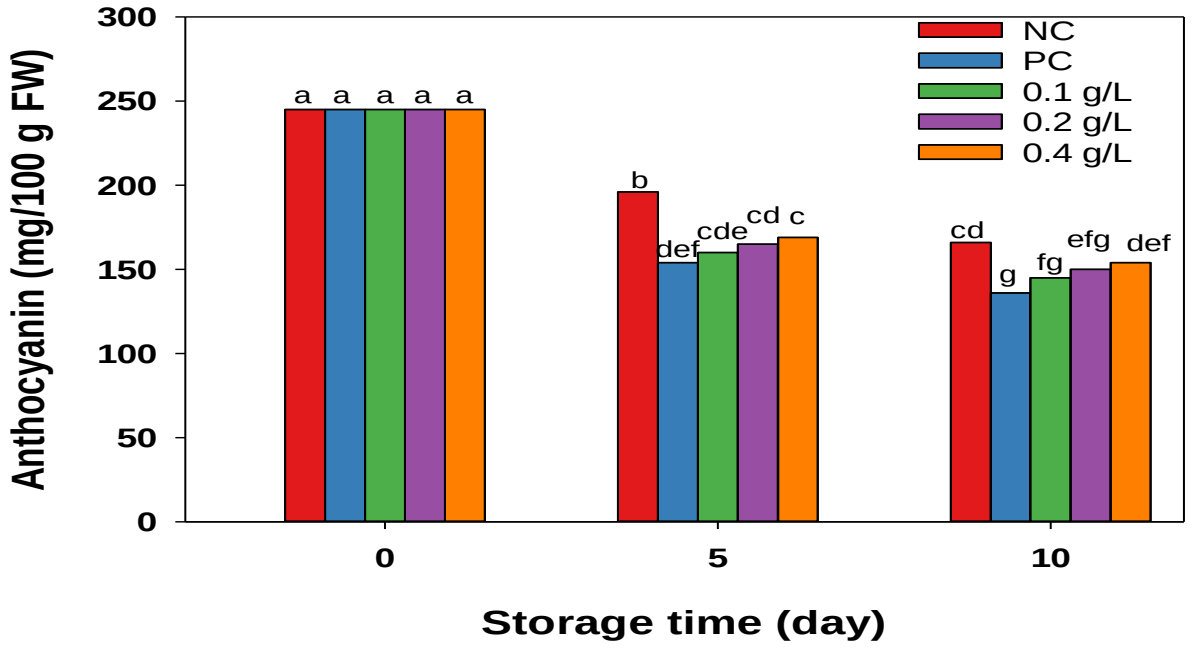

Figure 7. Effect of 7S globulin at different concentrations (0.1, 0.2, and 0.4 g/L) on anthocyanin (mg/100 g FW) in strawberry fruits inoculated with *B. cinerea* compared with negative and positive controls (NC and PC, respectively). Means followed different letters significantly differ according to Tukey's HSD test ($P \leq 0.05$).

DISCUSSION

Globally, one of the most harmful fungi that cause severe postharvest deterioration in fruits and vegetables is *B. cinerea* (Suirta *et al*., 2021; Kahramanoğlu *et al.,* 2022). In the presented study, isolating 7S globulin from pea seeds underwent evaluation as an antifungal agent in vitro against *B. cinerea* separated from infected strawberry fruits and in postharvest against inoculated strawberry fruits with *B. cinerea.* The major three subunits were notable in the fraction containing 7S globulin and the electrophoretic patterns of the 7S globulin isolated from pea seeds, making these results consistent with earlier research confirming the molecular identities of each one (Abdel-Shafi *et al.,* 2019a).

Categorizing main seed storage proteins of legumes has included two types, i.e., 11S globulin and 7S globulin (Sitohy *et al.,* 2012). The resemblance between the protein components of soybean and those of other legumes suggests probable similar functions and antifungal activities (Sitohy *et al.,* 2012; Osman *et al.,* 2014; Abdel-Shafi *et al.,* 2019a). The 7S globulin isolated from soybean seeds has previously been presented as an antifungal agent in vitro and in situ for controlling the development of the green mold growing on postharvest orange fruits (Osman *et al.,* 2016a). Similarly, 7S globulin isolated from chickpea seeds' application against *Alternaria tenuissima* taken from fig fruits in vitro and postharvest figs significantly extended the fruits' shelf life by reducing the disease severity by 73% (Abbas *et al.,* 2020).

The presence of 7S globulin reduced the mycelial growth of *B. cinerea* in a concentration-dependent manner. These results confirmed those of prior reports describing antifungal proteins obtained from different legumes, such as soybean (Osman *et al.,* 2016a), chickpea (Abbas *et al.,* 2020), lentil (Sitohy *et al.,* 2007), and African catfish (Abdel-Shafi *et al.,* 2019b). After exposure to the 7S globulin in PDA, scanning electron microscopy revealed deformation of the fungal hyphae, and appeared shriveled. This trait was evident in 7S-globulin-treated *B. cinerea*, and it may be connected to the protein-protein interaction that affects membrane permeability (Osman *et al.,* 2016b,c; Abdel-Hamid *et al.,* 2016). The 7S globulin served as a postharvest treatment on strawberry fruit, and the in situ results supported the in vitro findings into a potential application.

In the relevant study, exposure to 7S globulin at different concentrations reduced disease incidence and severity on strawberry fruits inoculated with *B. cinerea* in a concentration-dependent manner. In the disease incidence, the reduction and severity refer to the effectiveness of 7S globulin as an antifungal agent. The presented study estimated the effects of 7S globulin on strawberry fruit quality inoculated with *B. cinerea*. Weight loss, firmness, TSS, and anthocyanin content were crucial in estimating strawberry fruits' postharvest and market value.

Strawberry fruits lose weight, soften, and TSS degrades at room temperature. The prevailing investigations discovered that exposure to 7S globulin prevented fruit weight loss throughout storage and was liable to preserve fruit firmness, TSS, and anthocyanin levels. According to past studies, the 7S globulin could prevent bacterial and fungal growth on blueberry surfaces through interactions between proteins, maintaining the fruit's cuticle integrity and preventing water and weight loss, which would keep the fruit's turbulence and firmness (Sun *et al.,* 2021).

CONCLUSIONS

The current investigations discovered that 7S globulin (isolated from pea seeds) exhibits potent antifungal action against *B. cinerea* mycelial development via a membrane-targeted mechanism. They also might affect the hyphal morphology and compromised plasma membrane integrity. The 7S globulin also prevented postharvest gray mold on strawberry fruits. Likewise, the 7S-globulin exposure maintained fruit quality and congested the strawberry's natural deterioration.

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