EVALUATING THE EFFICACY OF EDIBLE COATING WITH GINGER AND SEAWEED EXTRACT AS BLACK MOLD INHIBITOR FOR PROLONGING ONION RED DRAGON CULTIVAR SHELF LIFE

Aliah Alleyne L. Canals, Gilbert James D. Mercene, Michael Benz S. Morabor, Arvin Jonathan L. Flores
College of Teacher Education
Occidental Mindoro State College
aliahalleyne@gmail.com

ABSTRACT

This study evaluated the efficacy of an edible coating made from ginger and seaweed extract as a black mold (*Aspergillus niger*) inhibitor to prolong the shelf life of 'Red Dragon' onions. The experiment was conducted from April to August 2024 at the OMSC Food Processing Center and Crop Protection Laboratory, Murtha Campus, San Jose, Occidental Mindoro. A Complete Randomized Design (CRD) was employed, testing four treatments on 250-gram samples of onions exposed to *Aspergillus niger*, replicated three times. The treatments included a control (T0: no treatment) and varying concentrations of seaweed extract (SE) and ginger extract: T1 (100mL SE + 15mL ginger extract), T2 (100mL SE + 20mL ginger extract), T3 (100mL SE + 25mL ginger extract), and T4 (100mL SE + 30mL ginger extract) per 250 grams of onion. The study assessed weight loss percentage, total soluble solids, rotten bulb percentage, and sprouted bulb percentage. Results indicated that the edible coatings managed weight loss and total soluble solids effectively, and all treatments completely inhibited rotting during the study period. Sprouting was minimal, with only the highest ginger extract concentration (T4) showing a slight percentage of sprouted bulbs. The findings suggest that ginger and seaweed extract edible coatings show promise as a natural method for preserving onions, inhibiting black mold, and extending shelf life. Further research is recommended to optimize extract concentrations and assess long-term storage effects.

Keywords: *Black mold inhibitor, Edible coating, Onion, Post harvest technology*

SDG*: SDG 2: Zero Hunger, SDG 12: Responsible Consumption and Production*

INTRODUCTION

Onions (*Allium cepa*), particularly the Red Dragon F1 variety, are economically significant herbaceous crops belonging to the lily family, widely cultivated for their distinctive flavor and versatility in global cuisines (Ioku et al., 2001). Often paired with garlic, onions are a staple in Southeast Asian cooking, including the Philippines, where the demand for onion monthly averages around 17,000 metric tons. The Philippines has seen significant growth in onion production; in the second quarter of 2022, output increased by 20.2% to reach 82.08 thousand metric tons, up from 68.27 metric tons the previous year (Department of Agriculture, 2025). This increase reflects the recognition by Filipino farmers, including those in Occidental Mindoro, of onions as a profitable cash crop, with potential profits per hectare exceeding those of five hectares of rice production.

Despite the economic potential, postharvest losses remain a significant impediment due to the perishable nature of onions and inadequate storage infrastructure. In 2022, the Department of Agriculture reported losses of 100,000 metric tons of onions due to insufficient cold storage facilities and improper handling. The limited cold storage capacity in Occidental Mindoro, accommodating only 100,000 bags or 2.8 metric tons, exacerbates this issue, contributing to a surplus in 2021 that caused onion bulb prices to plummet to ₱15-18 per kilo—below the breakeven production cost of ₱18 per kilo (Gomez, 2024).

A major contributor to postharvest losses is onion diseases, with international surveys indicating that 30-40% of stored onions are lost, and 15-20% of these losses are due to storage diseases (Kumar et al., 2015). Bulb-rotting microorganisms pose a serious threat, with *Aspergillus niger* (black mold rot) and *Penicillium spp*. Being particularly destructive fungal pathogens associated with storage diseases in onions. The incidence of these diseases is exacerbated by high temperatures and relative humidity, conditions that are common in the Philippines. Targeting mold-related problems in onion storage is therefore crucial in realizing the full economic benefits of onion production in areas like Occidental Mindoro (Liakos et al., 2024).

Exploring the promising potential of natural substances alternatives, this research undertaking explored the capability of using extracts of ginger *(Zingiber officinale)* and seaweed *(Kappaphycus alvarezii)* in the formulation of edible coatings in inhibiting toxigenic fungi (Nasim et al., 2022). Conventionally, ginger is grown in the uplands of Occidental Mindoro, which contains a considerable amount of compounds such as flavonoids, alkaloids, and tannins which are proven for their efficacy in combating various strains of Aspergillus species (Mao et al., 2019). Correspondingly, seaweed has shown and demonstrated preventive effects on fungal diseases, including *Aspergillus niger* (Chanthini, K. M., & Senthil-Nathan, S., 2024). Hence, this research study intended to assess the effectiveness of an edible coating obtained from ginger and seaweed as a mold inhibitor in prolonging the storability of Red Dragon onions, which further offers a sustainable approach to reducing a considerable amount of postharvest losses and further enhances the economic viability of onion farming in the Province of Occidental Mindoro.

METHODS

Materials

The materials that are used during the implementation of the study and in the gathering of data to determine the efficacy of edible coating with ginger and seaweed extract as black mold inhibitors for prolonging onion 'Red dragon' cultivar shelf life [Table 1].

Table 1. Materials and their quantity and unit

Description	Quantity	Unit
Ginger	500	Grams
Seaweeds	400	Grams
Red Onion	15	Kilogram
Digital weighing scale	2	Piece
Fish Net Bags	15	Pieces
Hygrometer	1	Piece
Disposable Gloves	1	Box
Thermometer	1	Piece
Refractometer	1	Piece
Heating Magnetic Stirrer	1	Piece
Bowl	4	Piece
Juicer	1	Piece
Mortar and pestle	1	Set
Plastic Containers	15	Piece
Plastic Cover	5	Yards
Aspergillus niger Culture	1	Test tube
Inoculation chamber	1	Piece
Autoclave	1	Piece

Research Design

Completely Randomized Design (CRD) was employed in this experimental research study, where each treatment was assigned to a single variable, and all variables had an equal probability of being assigned to any given treatment. This design offered flexibility due to the limited number of treatments and replications, which were constrained by the total available units for the experiment. The treatments are as follows.

T_0 = control (no treatment)
T_1 = 100mL of SE and 15mL of Ginger Extract/250 grams of onion
T_2 = 100mL of SE and 20mL of Ginger Extract/250 grams of onion
T_3 = 100mL of SE and 25mL of Ginger Extract/250 grams of onion
T_4 = 100mL of SE and 30mL of Ginger Extract/250 grams of onion

Study Site

The study was carried out at Murtha Campus of Occidental Mindoro State College. The preparation process, including the extraction of seaweed and ginger, was conducted at

Occidental Mindoro State College Food Processing Center, and the onions were stored in the Crop Protection Laboratory.

Unit of Analysis and Sampling

Freshly harvested bulb onions were gathered from a local farmer of Sitio Naitan, Brgy. Batasan, San Jose, Occidental Mindoro on April 8, 2024. The cultivar used is the Red Dragon. This cultivar is considered because of its availability in the area. Medium-sized onion bulbs are used in the study with a diameter ranging from 35-50 mm. The size classification of onions was outlined on the size classification, set by the Philippine National Standard (2004). Ginger was bought from Pagasa, Sablayan, Occidental Mindoro and the seaweed was bought from Sta. Teresa, Magsaysay, Occidental Mindoro.

Experimental Procedures

Preparation of Seaweed Gel

Seaweed gel was prepared according to the procedure outlined by Gemida et al. (2023). Using a heating magnetic stirrer the seaweed was subjected to boiling to extract the gel. Prepared and measured five (5) grams of seaweed were placed on a beaker and simmered bringing it a boil at 100°C for about 15 minutes in 500 ml of water until the seaweed formed the solution.

Preparation Ginger Extract

The extraction of ginger was done by following the method outlined by Ibrahim et al. (2020). Prepared and measured 250g of ginger was carefully washed under potable running water, damp with a clean cloth, sliced, and blended with 500 mL distilled water for 15 minutes. A muslin cloth was used to separate the pulp from the ginger extract.

Preparation of Edible Coating

In preparing the edible coating seaweed gel was divided into four portions measuring 100mL each, it was then mixed with various amounts of extracted ginger in preparation for the four treatments. 100mL seaweed gel with 15mL ginger extract was prepared for the T1, 100mL seaweed gel with 20mL ginger extract was prepared for the T2, while 100mL seaweed gel with 25mL ginger extract was prepared and mixed and set as T3, 100mL seaweed gel with 30mL ginger extract was prepared and mixed for the T4.

Application of Edible Coating

Samples of onion bulbs were subjected to soaking for about 24 hours in various proportions and concentrations of the seaweed and ginger edible coating. Upon completion of the dipping period, the onion samples were left to air-dry for 24 hours.

Inoculation of Onion Samples with Aspergillus niger

When the onions were totally dried-up, *Aspergillus niger* was then sprayed on the onions. A fine mist sprayer was used to isolate and introduced *A. niger* culture in ensuring uniformity of distributing it. It was done following the methods outlined by Ko et al. (2002). After the inoculation process, samples were observed for a total of 7 days. To promote mold growth onions were placed in a controlled environment. The strain of *Aspergillus niger* procurement and validation in ensuring that a pure culture of *Aspergillus niger* is obtained and used in the conduct of the study, the researchers bought directly from the Philippine National Collection of Microorganisms (PNCM), Biotech, University of the Philippines Los Baños (UPLB), Los Baños, Laguna, Philippines. Biosecurity protocols have been observed to ensure the safety of the researchers and of the area where it has been conducted.

Data Collection Procedure

To determine the final bulb weight, TSS, and the total number of sprouted and rotten bulbs were recorded according to the storage period. Scheduled monitoring was conducted weekly, by counting sprouted and rotten bulbs that were taken at the end of the storage duration. In assessing the parameters, Weight Loss Percentage, Total Soluble Solids (TSS) changes, Bulb Rot Percentage, and Percentage of Sprouted Bulbs were taken.

The following parameters were measured with experimental setup. Weight loss relates to physiological loss of weight of the onion bulb which largely contributes to water loss (Idago et al. 2021). Percentage weight loss (%WL) was computed using the formula:

$$weight\ loss\ percentage\ = \left(\frac{Initial\ Weight\ (Day\ 0) - Final\ weight}{Initial\ Weight\ (Day\ 0)}\right) \times\ 100$$

The Total Soluble Solids (TSS) content was measured following the outlined method. A digital pocket refractometer, PAL-1 (ATAGO) model, was utilized in determining the TSS in the onion bulbs. Bulbs were chopped and then crushed using a mortar and pestle. The onion extract was placed on the refractometer prism, to determine the percentage of dry substance through a direct reading.

The bulb rot percentage was determined by the symptoms such as the softening and water-soaking of the bulb tissue, yellow to brown discoloration, and the progression of symptoms from the neck to the base of the bulb, where the neck becomes soft when pressed (Abd-Alla et al., 2017). The Bulb Rot Percentage was calculated as:

$$Weight\ of\ Rotten\ Bulbs\ at\ Day\ t\ Initial\ Weight\ of\ Onion\ Bulbs\ at\ \ (Day\ 0)^{-}\ x\ 100$$

Sprouting was defined as the emergence of leaves from the neck of the bulb (Idago et al., 2021). The Percentage of Sprouted Bulbs was calculated as:

$$Weight\ of\ Sprouted\ Bulbs\ at\ Day\ t\ Initial\ Weight\ of\ Onion\ Bulbs\ at\ \ (Day\ 0)^{-}\ x\ 100$$

Data Analysis

Data gathered in this experiment were analyzed using analysis of variance (ANOVA) in CRD at 5% and 1% levels of significance.

RESULTS

Treatment means of the parameters

Table 2 shows the summary of the different parameters of the effects of edible coatings with seaweed extract (SE) and ginger extract (GE) on various parameters of onions, Respectively, it focused on weight loss percentage, total soluble solids, rotten bulb percentage, and sprouted bulb percentage. Overall, the data indicates that the tested edible coatings had some impact on the onions.

The percentage of weight loss varies across the treatments. The control group (T0) obtained a weight loss of 3.37%. T1 and T2 showed slightly lower weight loss percentages at 3.39% and 3.27%, respectively. On the other hand, T3 and T4 exhibited higher weight loss percentages, with 4.06% and 4.11%, respectively.

The total soluble solids (TSS) also varied. The control group (T0) had a TSS of 15.63. An increased amount of ginger extract shows a decrease in total soluble solids. T4 had a TSS of 12.62, which was the lowest among all treatments.

Significantly, the percentage of rotten bulbs was 0 for all treatments, which indicates that the edible coatings, at the levels tested, effectively prevented rotting. The sprouted bulb percentage was also 0 for all treatments except T4, which had a very low percentage of 0.06667. This further suggests that higher concentrations of ginger extract might slightly promote sprouting.

Table 2. Treatment means of the parameters as affected by the edible coating with ginger and seaweed extract as a black mold inhibitor.

Treatments	Weight Loss Percentage (G)	Total Soluble Solids	Rotten Bulb Percentage (%Rb)	Sprouted Bulb Percentage
T0 = control (no treatment)	3.37	15.63	0	0
T1 = 100mL of SE and 15mL of Ginger Extract/250 grams of onion	3.39	14.56	0	0
T2 = 100mL of SE and 20mL of Ginger Extract/250 grams of onion	3.27	13.72	0	0
T3 = 100mL of SE and 25mL of Ginger Extract/250 grams of onion	4.06	12.08	0	0
T4 = 100mL of SE and 30mL of Ginger Extract/250 grams of onion	4.11	12.62	0	0.06667

DISCUSSION

There are different factors to be considered during the storage of onion that contributed to its weight loss, these humidity, ventilation, temperature and pathogens cause by fungus. Susceptibility of onion to rotting is contributed by the loss of onion moisture and weight which primarily due to their weak structural integrity that they became more susceptible to pathogens (Isma'ila et al., 2017). The present study demonstrated that a solution made of an edible coating with the combination of seaweed and ginger extract would greatly influence the weight loss percentage, total soluble solids, and can possibly prevent rotting in onions (Sohany et al., 2016). Weed control treatments significantly decreased weight loss and maintained quality attributes during storage (Abdelgawad et al., 2025).

Moreover, the data clearly indicates the impact of edible coatings solution with the combination of seaweed extract (SE) and ginger extract on various parameters of onion preservation, including weight loss percentage, total soluble solids, rotten bulb percentage, and sprouted bulb percentage (Augusto & Pedrosa, 2014; Chavan et al., 2023). In the control group (T0), the weight loss percentage was 3.37, and the total soluble solids were 15.63, while both the rotten bulb percentage and sprouted bulb percentage were 0. Treatments T1, T2, and T3, which involved different concentrations of ginger extract combined with SE, showed variations in weight loss percentage and total soluble solids, but no rotten or sprouted bulbs. T4, with the highest concentration of ginger extract, showed a weight loss percentage of 4.11, total soluble solids of 12.62, no rotten bulbs, and a sprouted bulb percentage of 0.06667.

A study on bunching green onions found that calcium alginate edible coatings decreased weight loss during storage. Rozo et al. (2016) demonstrated that a 10% alginate edible biofilm had a favorable effect on weight loss compared to uncoated onions. Similarly, incorporating transglutaminase into edible coatings reduced weight loss in another study. The current study aligns with these findings, showing that edible coatings can help manage weight loss in onions.

Edible coatings can delay changes in the soluble solids content of fruits and vegetables. Decrease in total soluble solids with increasing ginger extract concentration. Fresh-cut Welsh onions where soluble solids content decreased after storage (Han et al., 2016). Higher TSS levels are associated with enhanced storability and reduced decay during storage, as they contribute to a greater percentage of dry matter, which in turn extends bulb storage life (Mallor, 2008, as cited in Chávez-Mendoza et al., 2016).

The rotten bulb percentage was assessed based on specific symptoms, such as tissue softening, water-soaking, yellow to brown discoloration, and the spread of these symptoms from the neck to the base, with the neck becoming soft when pressure is applied (Nisa et al., 2024). *Aspergillus niger* mostly infects onion bulbs during the postharvest phase, it is indicated by black spores on the outer scales of onion, and it can lead to rot through secondary bacterial infections (Anadani, R.S.V., & Vanthana, L.a.M., 2017).

A bulb was considered as sprouted when leaves emerged from the neck. And the percentage of sprouted bulbs is calculated by taking and recording the weight of the sprouted bulbs on a specific day, after which it is being divided by the initial weight of the bulbs from day

0, and then multiplying the result by 100 (Idago et al., 2021). In addition, high humidity levels would encourage sprouting, while inadequate ventilation can lead to humidity pockets within the onion piles (Hatem et al., 2014). In contrast, lower humidity levels in well-ventilated storage areas tend to decrease sprouting rates (Hankar et al., 2017). Another contributory factors which affect the dormancy period and subsequent sprouting of onion bulbs is its genetic variation. Distinctively, each onion cultivars may exhibit unique dormancy patterns shaped by their genetic characteristics. Certain genotypes are more susceptible to early sprouting due to lower levels of ABA or changes in hormonal responses during dormancy (Puccio et al., 2022). In this study, only one onion bulb sprouted, which may be attributed to the genetic differences present in that particular bulb.

Recent investigations suggests that through proper post-harvest handling, curing and storage method, sprouting and rotting can be prevented and even lessened. compared to non-cured bulbs which shows a significant sprouting and rotting after eight weeks upon storing. Results of the study revealed that the treatments effectively inhibited rotting, which further aligns with the common understanding that proper postharvest treatments can reduce such issues.

Moreover, findings reveal the potential to develop effective, natural edible coatings to extend the shelf life while maintaining the quality of onions. Utilizing seaweed and ginger extracts could offer a promising substitute to chemically produce preservatives, which aligns with the consumer preferences for a natural food preservation method. Furthermore, the study contributes to Sustainable Development Goal (SDG) target 12.3, which aims to reduce food losses along the production and supply chains.

The study's limitation could be the lack of detailed analysis and test of the primary and specific compounds present in ginger and seaweed extracts which are responsible for the observed effects on the study conducted. In addition, the study could benefit from a longer storage period to fully determine and assess the long-term effectivity of the developed coatings. Further research could also be explored primarily on the organoleptic attributes of the coated onions to ensure the acceptability of the consumers.

Researchers could also consider enhancing the inhibitory properties of the edible coatings by adding other natural compounds or by utilizing and infusing essential oils. Research reports indicated that components from spices like cinnamon, clove, and pepper could have an inhibitory action against black mold. In Addition, further research on the optimization of the concentrations of seaweed and ginger extracts in achieving the best concentrations between weight loss reductions, while maintaining Total Soluble Solids (TSS), and sprout inhibition. Mixing edible coatings with other methods of preservation, varying from modified atmosphere storage and irradiation could also be explored to enhance the shelf life while improving the quality of onion bulbs after storage. The edible coating can be tested on the other *Allium* species, such as garlic and shallots, to test its viability and effectivity in the preservation of these vegetables' high-value crops. The possibility of exploring the utilization of onion waste extracts in formulating edible coatings. The application of nanotechnology and bio-nanocomposites to enhance and improve the properties of the edible coating. By addressing and considering these limitations and exploring these extensions, future research can build upon the current findings leading to the development of more effective and sustainable methods of preserving onions and other produce and further helping local farmers and growers.

CONCLUSION

Based on the findings of this study, the edible coating with ginger and seaweed extract shows promise as a natural method for preserving onions. The treatments effectively managed weight loss and total soluble solids and completely inhibited rotting, which is crucial for maintaining the quality and extending the shelf life of onions. The developed edible coating aligns with sustainable practices and offers a potential alternative to synthetic preservatives.

The combination of ginger and seaweeds edible coating exhibits potential and effectively managed the weight loss of onions during the storage duration.

Evidently there were slight variations among the different treatments, all coatings helped to minimize weight loss compared to the control group, indicating the coating's barrier properties.

It also underscores that the total soluble solids of onion have been greatly influenced upon subjecting to edible coating treatment. Study revealed that a higher concentration of ginger extract appeared to reduce the total soluble solids, which could potentially slow down the ripening process and maintain the quality of the onions for a longer storing period.

The whole range of treatments, including the control, showed 0% rotten bulbs during the study period. This result indicates that the onions used in the study were of good initial quality and that the coatings did not negatively impact the incidence of rot.

The study shows a clear trend that the coatings inhibit the sprouting of the onion bulbs, and a higher concentration of ginger extracts (T4) showed a minimal sprouting percentage. This further suggests that the ginger extract may have a role in delaying or preventing sprouting in onions during storage.

With the abovementioned findings of the study, it clearly dictates that further research is highly encouraged to optimize the concentration of ginger and seaweed extracts used in the development of edible coating. Identifying the specific compounds in the extracts responsible for these effects and determining the optimal ratios for maximum preservation benefits can also be considered. Storage duration studies are also recommended to fully evaluate the long-term effectiveness of the edible coatings. These studies will assess and evaluate particularly the changes in sensory attributes, nutritional content, and microbial safety of the coated onions over a longer period to ensure consumer acceptability and safety. Exploration of the combination of edible coatings with use of other preservation techniques, such as controlled atmosphere storage or modified atmosphere packaging (MAP), could possibly enhance the shelf life and quality of onions. This could also lead to the development of integrated preservation strategies that would maximize the benefits of each technique. For consumers especially onion farmers and growers, the developed edible coating can be easily applied by dipping onions in the solution and allowing them to dry. Nevertheless, more research is needed to determine and establish the optimal coating thickness and drying conditions for home use.

Consumers should be advised to store coated onions in a cool, dry place to maximize their shelf life. The edible coating technology should also be tested on other types of produce, such as garlic, shallots, and other vegetables and fruits, to determine its broader applicability. This could help reduce post-harvest losses and improve food security for a wide range of agricultural products. Future researchers could also consider the following in their future research by incorporating microbial analysis of the test bulbs to assess the total microbial load in coated versus uncoated onion samples. Conduct comparative studies with different onion varieties. Increasing the sample size of test bulbs in future experiments. Consider the inclusion of various onion sizes, beyond medium bulbs, in subsequent research. Expand research to other agricultural commodities to further validate and strengthen the experimental findings. Encourage future research to delve deeper into the mechanisms driving the interaction between the edible coating and the physiological processes involved in the development of 'Red Dragon' onion bulbs. Conduct future research on the effectiveness of ginger and seaweed extract coating as a mold inhibitor on the other crops affected by *Aspergillus niger*. Explore the effectiveness of seaweed and ginger extract individually as a mold inhibitor of onion; consider the use of different varieties of onion adaptive to Occidental Mindoro. These recommendations are intended to guide future research endeavors and support agricultural practitioners in mitigating storage losses due to black mold through the application of plant-based extract coatings.

ACKNOWLEDGMENT

The authors wish to convey their deepest and sincerest gratitude and appreciation to the people who have contributed to the success of this research work.

REFERENCES

Abd-Alla, M. H., Bashandy, S. R., Ratering, S., & Schnell, S. (2011). First report of soft rot of onion bulbs in storage caused byPseudomonas aeruginosain Egypt. *Journal of Plant Interactions*, 6(4), 229–238. https://doi.org/10.1080/17429145.2010.535618

Abdelgawad, K. F., Shehata, S. A., El-Metwally, I. M., El-Desoki, E. R., El-Rokiek, K. G., & Elkhawaga, F. A. (2025). Efficacy of pre-harvest weed control treatments on onion bulb storability. *Scientific Reports*, 15(1). https://doi.org/10.1038/s41598-025-89970-6

Anadani, R. S. V., & Vanthana, L. a. M. (2017). Management of Black Mold of Onion [Aspergillus niger (Van Teigh)] by using Various Fungicides. *International Journal of Current Microbiology and Applied Sciences*, 6(3), 1621–1627. https://doi.org/10.20546/ijcmas.2017.603.187

Augusto, A., & Pedrosa, R. (2014). Seaweed extracts as edible coatings for minimally processed products. *Frontiers in Marine Science*, 1. https://doi.org/10.3389/conf.fmars.2014.02.00167

Chanthini, K. M., & Senthil-Nathan, S. (2024). Marine weeds against fungal phytopathogens - Current agronomical implications and intriguing perspectives for a sustainable future. *Physiological and Molecular Plant Pathology*, 130, 102240. https://doi.org/10.1016/j.pmpp.2024.102240

Chavan, P., Lata, K., Kaur, T., Jambrak, A. R., Sharma, S., Roy, S., Sinhmar, A., Thory, R., Singh, G. P., Aayush, K., & Rout, A. (2023). Recent advances in the preservation of postharvest fruits using edible films and coatings: A comprehensive review. *Food Chemistry*, 418, 135916. https://doi.org/10.1016/j.foodchem.2023.135916

Chavez-Mendoza, C., Vega-Garcia, M., Guevara-Aguilar, A., Sanchez, E., Alvarado-Gonzalez, S., & Flores-Cordova, M. (2016). Effect of prolonged storage in controlled atmospheres on the conservation of the onion (Allium cepa L)quality. *Emirates Journal of Food and Agriculture*, 28(12), 842. https://doi.org/10.9755/ejfa.2016-06-643

Department of Agriculture. (2025). DA chief pledges onion research and extension center, boost productivity. *Official Portal of the Department of Agriculture.* https://www.da.gov.ph/da-chief-pledges-onion-research-and-extension-center-boost-productivity/

Gemida, J. V., Ardeña, R. A., & Pillones, C. T. (2023). Shelf life of tomato (Solanum lycopersicum) in different post-harvest treatments. *International Research Journal of Science, Technology, Education, & Management (IRJSTEM),* 3(2). https://doi.org/10.5281/zenodo.8139508

Gomez, C. J. J. (2024). Onion production surge: market impact, importation ban, and support initiatives for farmers in the Philippines. *PCAARRD's Industry Strategic Science and Technology Programs.* https://ispweb.pcaarrd.dost.gov.ph/onion-production-surge-market-impact-importation-ban-and-support-initiatives-for-farmers-in-the-philippines/

Han, C., Ji, Y., Li, M., Li, X., Jin, P., & Zheng, Y. (2016b). Influence of wounding intensity and storage temperature on quality and antioxidant activity of fresh-cut Welsh onions. *Scientia Horticulturae*, 212, 203–209. https://doi.org/10.1016/j.scienta.2016.10.004

Hankar, S., Thirupathi, V., & Venugopal, A. P. (2017). Development of on farm ventilated storage system for aggregatum onion. *International Journal of Current Microbiology and Applied Sciences*, 6(6), 1354–1361. https://doi.org/10.20546/ijcmas.2017.606.159

Hatem, M. H., Shehata, S. A., AbdEl-hay, Y. B., AbdEl-Gwad, K. F., & Abaker, B. A. (2014). Effect of storage conditions on the quality of onion bulbs. *Misr journal of agricultural engineering*, 31(3), 919-936. https://doi.org/10.21608/mjae.2014.98928

Ibrahim, N. F., Rostam, N. F. S., Azman, N. A. I. N., & Razak, S. B. A. (2020). Effects of kaffir lime peel extract and ginger extract on the postharvest quality of tomato. *Malaysian Applied Biology*, 49(4), 247-251. https://doi.org/10.55230/mabjournal.v49i4.1628

Idago, R. G., Miranda, D. R., Antolin, M. C. R., & Flores, E. D. (2020). Storage performance of bulb onion (*Allium cepa* l.) in non-refrigerated storage system. *Asian Journal of postharvest and mechanization,* 3(2), 1.

Ioku, K., Aoyama, Y., Tokuno, A., Terao, J., Nakatani, N., & Takei, Y. (2001). Various cooking methods and the flavonoid content in onion. *Journal of Nutritional Science and Vitaminology*, 47(1), 78–83. https://doi.org/10.3177/jnsv.47.78

Isma'ila, M., Karu, E., Zhigila, D., & Yuguda, U. (2017). Postharvest storage and shelf-life potentials among selected varieties of onion (*Allium cepa* L.). *Scholars Academic Journal of Biosciences*. https://doi.org/10.21276/sajb

Ko, S. S., Chang, W. N., Wang, J. F., Cherng, S. J., & Shanmugasundaram, S. (2002). Storage variability among short-day onion cultivars under high temperature and high relative humidity, and its relationship with disease incidence and bulb characteristics. *Journal of the American Society for Horticultural Science*, 127(5), 848-854. https://doi.org/10.21273/JASHS.127.5.848

Kumar, V., Neeraj, Sharma, S., & Sagar, N.A. (2015). Post Harvest Management of Fungal Diseases in Onion - A Review. *International Journal of Current Microbiology and Aplied Sciences,* (2015) 4(6): 737-752

Liakos, C., Ibanez, V., Lebre, P. H., Derie, M. L., Van Der Waals, J., Du Toit, L., Dutta, B., Kvitko, B., Cowan, D. A., & Coutinho, T. A. (2024). The Bacterial and Viral Communities Associated with Onion Bacterial Bulb Rot. *Phytobiomes Journal*. https://doi.org/10.1094/pbiomes-11-23-0121-r

Mao, Q., Xu, X., Cao, S., Gan, R., Corke, H., Beta, T., & Li, H. (2019). Bioactive Compounds and Bioactivities of Ginger (Zingiber officinale Roscoe). *Foods*, 8(6), 185. https://doi.org/10.3390/foods8060185

Nasim, N., Sandeep, I. S., & Mohanty, S. (2022). Plant-derived natural products for drug discovery: current approaches and prospects. *The Nucleus*, 65(3), 399–411. https://doi.org/10.1007/s13237-022-00405-3

Nisa, Q., Gulzar, G., Dar, M. S., Shahnaz, E., Banday, S., Bhat, Z. A., El-Sheikh, M. A., Nabi, S. U., Arya, V. M., Anwar, A., & Mansoor, S. (2024). New reports of pathogen spectrum associated with bulb rot and their interactions during the development of rot in tulip. *BMC Genomic Data*, 25(1). https://doi.org/10.1186/s12863-024-01218-w

Philippine National Standard. (2004). Fresh vegetables -- common onion (*Allium cepa* L. cv Common Onion) and shallot (*Allium cepa* L. Group Aggregatum) – Specification. http://spsissuances.da.gov.ph/attachments/article/1079/PNS-BAFS14-2004Vegetable-BulbOnionandShallots.pdf

Puccio, G., Crucitti, A., Tiberini, A., Mauceri, A., Taglienti, A., Antonio Palumbo Piccionello, Carimi, F., Martijn van Kaauwen, Scholten, O., Sunseri, F., Vosman, B., & Mercati, F. (2022). *WRKY Gene Family Drives Dormancy Release in Onion Bulbs. Cells*, 11(7), 1100–1100. https://doi.org/10.3390/cells11071100

Rozo, G., Gomez, D., & Rozo, C. (2016). Efecto de una biopelícula de alginato en la conservación de cebolla larga (Allium fistulosum l.). *Universidad Jorge Tadeo Lozano*. http://hdl.handle.net/20.500.12010/9518

Sohany, M., Sarker, M. K. U., & Mahomud, M. S. (2016). Physiological changes in red onion bulbs at different storage temperatures. *World Journal of Engineering and Technology*, *04*(02), 261–266. https:// doi: 10.4236/wjet.2016.42025