

ARTICLE**Impact of banana shell powder on productive and physiological traits of laying hens****Saad Mohammed Hussein Kazem***Department of Animal Production, College of Agriculture, University of Al-Qasim Green, 51013, Iraq***ABSTRACT**

The aim of the experiment was to find out the influence of various amounts of banana peel powder on physiological and biochemical parameters of the hens. For the research one hundred and twenty ISA Brown layering hens were selected and allocated in four test groups containing thirty chickens each. These hens were then divided into three replicates of 10 hens each. Three levels of banana peel powder (3, 2, 1%) were added. The results showed that the treatment with the addition of (3%) banana peel powder (T4) was superior in terms of Hen Day egg (H.D) production (67.10%), Egg weight (E.W) (64.83 g), and Relative egg shell weight (R.E.S.W) (6.46%). As for the quality of the laying hens' eggs, the treatment (T4) was also superior in both Relative albumin weight (R.A.W) and Relative yolk weight (R.Y.W). As for the biochemical characteristics, both Cholesterol and Triglyceride (T.G) decreased significantly in all banana peel powder treatments. In contrast, they had no significant effect on liver enzymes, while Glutathione (G.S.H) levels increased significantly in the treatment (T4). Therefore, we recommend adding (3%) banana peel powder to the diets of laying hens due to its positive effects on production levels, lipids, and antioxidants.

Keywords: *Banana shell powder; Glutathione; Yolk height; Egg Production; Antioxidants.*

Corresponding Author: Saad Mohammed Hussein Kazem

E-mail: saad.mohamed@uogasim.edu.iq

Citation: Kazem, S. M. H. (2026). Impact of banana shell powder on productive and physiological traits of laying hens. *Misan Journal of Agricultural and Environmental Sciences*, 26(3), 1–7. <https://doi.org/10.64333/MJAE.26.3.1>

Received: 21/06/2026

Accepted: 03/08/2026

Published: 30/09/2026

DOI: <https://doi.org/10.64333/MJAE.26.3.1>

Copyright © 2026. This is an open-access article distributed under the Creative Commons Attribution License.

INTRODUCTION

Bananas rank among the most consumed and produced fruits in the world, with global production surpassing 115 million tons per year. Banana peel accounts for around 30–40% of the entire body mass of the fruit (Scott, 2021; Waraczewski and Sołowiej, 2024; Vlaicu and Untea, 2024). Among the top banana producing countries are India and Ecuador (Islam *et al.*, 2023). Such production amounts to considerable production waste, which is found in banana producing nations. In the past, the peel was perceived as being economically useless but is currently viewed as an abundant source of various bioactive compounds beneficial from both nutrition and health perspectives, especially when dealing with animals (Vlaicu and Untea, 2024). The following studies reveal that there are high levels of total phenolic compounds in banana peels ranging from 60.39 to 115.70 mg/g (gallic acid equivalent) as well as 973.08 mg/100g of rutin, 1130 mg/100g (tannins equivalent), 196 mg/g (quercetin flavonoid equivalent), dopamine, and carotenoids (Hikal *et al.*, 2022). All these are antioxidants with the ability to counteract oxidative stress. Banana peels are also abundant sources of various essential minerals, which include calcium ranging from 173.33 to 178.33 mg/100 g, potassium ranging from 75.00 to 76.67 mg/100 g, magnesium ranging from 38.33 to 43.33 mg/100 g. In terms of nutrition, carbohydrate has been reported to be the dominant compound, contributing (63.82%) to the total, followed by dietary fiber (12.67%), ash (9.56%), and protein (3.23%), with fat being less than (0.8 %). Although banana peels are used less frequently in poultry feed compared to other fruit waste, they have promising potential in egg

production, antioxidants, and fats. Therefore, the current study aims to demonstrate the effect of different levels of banana peel powder on the physiological and biochemical properties of eggs and laying hens.

MATERIALS AND METHODS

The experiment was carried out at a farm of layers in the district of Al-Kifl, governorate of Babylon, between October 1, 2023, and December 30, 2023. Eighty-four ISA Brown laying hens, which were eighty-weeks old, participated in the study. Four experimental groups were formed by grouping the hens into groups of twenty-one laying hens in each. Then, each of these four groups was subdivided into three subgroups, each containing ten laying hens. These layers were fed with a feed ration of 2860 kcal/kg of metabolic energy and 16% of crude protein.

The group distribution can be illustrated as follows:

T1: without adding.

T2: adding 1% banana peel powder/ kg diets.

T3: adding 2% banana peel powder/ kg diets.

T4: adding 3% banana peel powder/ kg diets.

- Performance attributes for productivity were investigated based on the technique of [Aljebory et al. \(2021a&b\)](#). Weekly information from all replicate samples was gathered and then averaged at the end of fifty-six days.
- The physiological traits were examined by applying the technique proposed by [Salman et al. \(2024&2025\)](#) and [Arkan et al. \(2025\)](#) where three replicates of each sample were considered, and blood concentrations were estimated after the experiment period.
- Statistical analysis was performed using [Duncan \(1955\)](#) multiple range test in the [SAS software \(2012\)](#).

RESULTS AND DISCUSSION

1- Physiological characteristics

The results in Table (1) show the effect of adding banana peel powder on the productivity of laying hens. Treatments (T3 and T4) significantly outperformed ($P \leq 0.05$) in hen-day egg production (H.D %) by 68.55% and 67.10%, respectively, compared to the control treatment (T1) which reached 64.65%. The control treatment did not differ significantly from treatment (T2). Regarding egg weight, treatment (T4) also significantly outperformed ($P \leq 0.05$), recording the highest average of 64.83 g, compared to the control treatment which recorded 61.23 g. Treatment (T2) did not differ significantly from the control treatment (T1). As far as the eggshell weight is concerned, it was found that treatment (T4) proved to be significantly better than the control (T1) with respect to eggshell percentage with a value of 6.46% compared to 6.12% in case of treatment T1. Treatments T1, T2, and T3 were not significantly different from one another. With regard to eggshell thickness, there were no significant differences among the various treatments. It was found from the above analysis that addition of 3% banana peel powder helped in obtaining optimum values for all characteristics (egg production percentage, egg weight, and relative eggshell weight). This was proven by the results of [Salas and Fontanilla \(2025\)](#) which found that the inclusion of 10% banana peels significantly increased Hen Day egg production ($P \leq 0.05$). Likewise, [Araya et al. \(2021\)](#) stated that addition of 25% banana peel powder into the corn feed resulted in maximum weight gain and egg production of the hens. Moreover, it was shown that addition of banana components in laying hen diets (3%, 6%, and 9%), either with or without addition of 1000 mg of different enzymes, increased significantly egg production, especially when the content of banana peel is 3%. At the same time, feed containing 9% banana peel caused a significant decrease in egg production and weight. Better performance in terms of daily egg production, weight, and shell is due to the biological components present in the banana

peel powder. When these components get absorbed in the body due to ingestion, they work upon the metabolism of oxidative stress, immunity, and nutrient absorption (Kpodo and Proszkowiec-Weglarz, 2023; Surai *et al.*, 2019).

In the period when the hen is producing eggs, the bird becomes vulnerable to oxidative stress, posing a risk to the health of the animal and the quality of the eggs produced (Bryden *et al.*, 2021; Emami *et al.*, 2020). Antioxidants help reduce the ROS by donating electrons (Jomova *et al.*, 2023; Aranda-Rivera *et al.*, 2022). Since banana peel is rich in polyphenols, the hens become resistant to all kinds of ROS and thereby contribute to good health conditions and increased egg production (Sugihartoet *et al.*, 2023; Oliveira *et al.*, 2023). Yet, the research results contrast sharply with the studies by Şengül *et al.* (2025), in which incorporation of banana peel at 0%, 2.5%, 5.0%, and 7.5% had no impact on hen-day egg production and egg weight. This was also true for the works of Shumye *et al.* (2022) and Djulardi *et al.* (2024).

Table (1) Effect of adding banana peel powder on productive of laying hens

Treat.	H.D %	E.W (g)	RESW %	EST (mm)
T1	64.65 ^c	61.23 ^b	6.12 ^b	0.34
T2	63.16 ^c	62.38 ^b	6.23 ^b	0.32
T3	68.55 ^a	60.52 ^c	6.04 ^b	0.33
T4	67.10 ^a	64.83 ^a	6.46 ^a	0.35
SEM	0.11	0.21	1.02	3.00
P-Value	0.05	0.05	0.05	NS

The results in Table (2) showed that there were no significant differences between the different treatments in the characteristics of albumin height and yolk. On the other hand, the treatment (T4) showed significant superiority ($P \leq 0.05$) in the relative albumin weight by a percentage of (38.89%) compared to the treatment (T1), which amounted to (36.73%) and did not differ significantly with the treatment (T3). As for the relative yolk weight, the treatment (T4) also excelled. It recorded the highest percentages of (19.43%) compared to treatment (T1), which reached (18.36%), and the other treatments did not differ significantly between them. Such results correlate with the results of the study conducted by Şengül *et al.* (2025) on laying quails in which the addition of banana peel powder in the quantities of 0%, 2.5%, 5.0%, and 7.5% did not cause any changes in the amount of albumin and yolk (only the color of the yolk).

This finding is also in agreement with the results provided by Shumye *et al.* (2022), where no significant influence of banana peel powder additions at different concentrations of 6%, 12%, and 18% was found on albumin. The reason for the lack of significant differences in albumin height and yolk weight between treatments may be that the components of banana peel powder do not directly affect the physical composition of the egg, but rather their effect is mostly on the metabolic or chemical aspects within the bird's body, represented by antioxidants or fat metabolism, as our results showed. Therefore, these characteristics remain within the normal physiological limits for laying hens. In contrast, a study by Kanbur *et al.* (2023) stated that adding dried banana leaves at a rate of 3% can improve egg quality parameters. In contrast, the significant superiority of the treatment with 3% banana peel powder (T4) in the relative weight of albumin and yolk can be attributed to the presence of phenolic compound in banana peel.

Ibrahim and Salem (2013) study stated that banana peel contains four times the number of phenolic compounds found in banana pulp. Such substances lower the oxidative stress and improve protein and fat utilization processes inside the body of the bird; this leads to more balanced nutrition in the egg, as well as increased quantities of albumin and yolk inside the egg (Akram *et al.*, 2022).

Table (2) Effect of adding banana peel powder on laying hens' egg quality

Treatments	A.H (m)	Y.H (m)	R.A.W %	R.Y.W %
T1	5.17	0.94	36.73 ^b	18.36 ^b
T2	5.13	0.98	37.42 ^b	18.71 ^b
T3	5.21	1.11	36.31 ^{ab}	18.15 ^b
T4	5.18	0.98	38.89 ^a	19.43 ^a
SEM	1.54	1.23	0.04	0.03
P-Value	NS	NS	0.05	0.06

3- Biochemical characteristics

Table (3) showed that there was no significant difference in the level of Total protein and Uric acid between the different treatments, as the treatment (T2, T3, T4) recorded a significant decrease in Cholesterol levels of (173.21, 162.45, and 173.21) compared to the control treatment (T1) which recorded the highest levels (200.10). As for Triglyceride, the treatments adding banana peel powder at a level of (3, 2, and 1%) also recorded a significant decrease ($P \leq 0.05$) of (154.32, 141.42, and 147.10) compared to the control treatment (T1) which reached a level of (162.20). The outcomes found here are similar to the study conducted by [Leke et al. \(2022a\)](#), where it was found that inclusion of banana flour in the diet of laying hens at different percentages of (5, 10, 15, and 25%) led to the reduction of total cholesterol in the blood. [Haryanto et al. \(2016\)](#) also stated that adding banana peel powder at a rate of (30%) caused a decrease in the cholesterol level to a level of (108.07mg/dl). In contrast, adding banana peel powder caused Bananas (40%) raise triglyceride levels up to (193.33 mg/dl). The study of [Leke et al. \(2022b\)](#) also showed that eating kapok bananas at different levels can reduce the level of cholesterol in eggs, and the reduction in fat levels (cholesterol and triglycerides) can be attributed to the flavonoids contained in banana peel powder, as [Farida et al \(2009\)](#) mentioned that the flavonoids found in banana peel can enhance the activity and levels of the lipoprotein lipase enzyme, which leads to lowering fat levels. Moreover, [Tian et al. \(2011\)](#) proved that flavonoids inhibit the activity of the fatty acid synthase enzyme, which is one of the main enzymes involved in fat metabolism. Inhibiting the function of this enzyme directly leads to a reduction in fatty acid formation, and thus a decrease in fatty acid levels may be reflected in a decrease in the formation of triglycerides and cholesterol ([Haryanto et al., 2016; Farida et al., 2009](#)). The results differ with the study of [Şengül et al. \(2025\)](#), that did not observe any effects on cholesterol content upon incorporation of banana peel powder at various levels (0%, 2.5%, 5.0%, and 7.5%).

Table (3) Effect of adding banana peel powder on Total protein and lipid profile of laying hens

Treat.	T.P	Chole.	T.G	U.A
T1	4.31	200.10 ^a	162.20 ^a	1.50
T2	4.28	190.52 ^b	154.32 ^b	1.60
T3	4.32	162.45 ^d	141.42 ^c	1.61
T4	4.39	173.21 ^c	147.10 ^c	1.52
SEM	1.66	5.16	4.90	1.75
P-Value	NS	0.05	0.05	NS

Table (4) reveals that there are no significant differences in adding banana peel powder at levels (3, 2, and 1%) in the levels of liver enzymes (ALT and AST) in laying hens. In contrast, the same table showed that there are significant differences in the levels of Glutathione, as the treatment (T4) recorded the highest levels, reaching (7.12), significantly ($P \leq 0.05$) compared to the control treatment (T1), which reached (4.94). The same is true for the two treatments. (T2, and T3) also recorded a significant increase compared to the control treatment (T1), and they did not differ significantly between them. These results are consistent with the study by [Şengül et al. \(2025\)](#), which showed no significant differences in liver enzymes (ALT, AST) in laying quail. Likewise, according to [Sugiharto et al. \(2020\)](#), in the research on the impact of the addition of banana peel on broilers, there were no differences between the groups in AST and ALT levels of liver enzymes. This might have been caused by the presence of biological active substances in the banana peel powder used for the different additives' combinations (3, 2, and 1%). They include polyphenols, flavonoids, and tannins that possess an ability of

antioxidation. Such substances enhance the number of antioxidants, including GSH. This can be observed in our experiments. The increased number of antioxidants will protect cells from damage, keeping them functioning normally without the impact on enzyme activities, while antioxidants' amounts are growing (Vlaicu and Untea, 2024; Hikal *et al.*, 2022).

Table (5) Effect of adding banana peel powder on liver enzyme of laying hens

Treatments	ALT (U /L)	AST (U /L)	G.S.H
T1	69.41	4.11	4.94 ^c
T2	58.23	3.96	5.73 ^b
T3	61.41	4.03	5.81 ^b
T4	63.22	4.14	7.12 ^a
SEM	6.74	3.61	0.09
P-Value	NS	NS	0.05

CONCLUSIONS

The current study revealed that adding banana peel powder at a level of (3 %) to the feed increases the daily egg production rate, egg weight, relative eggshell weight, and relative albumen and yolk weight. In contrast, it reduces cholesterol and triglyceride levels in laying hens and increases antioxidant (GSH) levels.

Disclaimer: None

Conflict of interest: The authors declare that they have no relevant financial or non-financial interest to disclose. **Funding disclosure:** None

REFERENCES

- Akram, T., Mustafa, S., Ilyas, K., Tariq, M. R., Ali, S. W., Ali, S., & Basharat, Z. (2022). Supplementation of banana peel powder for the development of functional broiler nuggets. *PeerJ*, 10, e14364.
- Al-Jebory H. H., Elsagheer M. A.b, Salman K. A., Al-Khilani F. M., Ibrahim D. K., Ibrahim K. R., Mahmoud K. F. 2023. Impact of aqueous extracts of Borage and Melilotus plants on some egg quality traits for laying hen. *Archives of Agriculture Sciences Journal*. 6(3): 73–81.
- Al-Jebory HH, Al-Saeedi MKI, Ajafar M, Ali NAL (2024). Impact of melatonin on improving productive traits of broiler exposed to environmental stress. *Adv. Anim. Vet. Sci.* 12(4): 775-781. <https://dx.doi.org/10.17582/journal.aavs/2024/12.4.775.781>.
- Al-Jebory, H.H., and S.A.H. Naji. 2021 b. Effect of Pelleted Fermented Feed in Production Performance of Laying Hens. Fourth International Conference for Agricultural and Sustainability Sciences IOP Conf. Series: Earth and Environmental Science 910 (2021) 012007 IOP Publishing doi:10.1088/1755-1315/910/1/012007.
- Aljebory, H.H.D., S.A.H. Naji. 2021 a. Effect of Pelleted Fermented Feed-in Egg Quality of Laying Hens. *Diyala Agricultural Sciences Journal* 13 (1): 41-57. <https://dx.doi.org/10.52951/dasj.21130105>.
- Aranda-Rivera, A. K., Cruz-Gregorio, A., Arancibia-Hernández, Y. L., Hernández-Cruz, E. Y., & Pedraza-Chaverri, J. (2022). RONS and oxidative stress: an overview of basic concepts. *Oxygen*, 2(4), 437-478.
- Araya, H. G., Gebrekristos, S. G., & Oliver, W. V. (2021). Effects of banana peels on chicken weight gain and egg production in the urban and peri-urban areas of Aksum City, Ethiopia.
- Arkan NB, Al-Jebory HH, Al-Khafaji FRA (2025). Impact of nano-encapsulated of anti-bacterial peptide on broiler growth performance under oxidative stress condition. *Adv. Anim. Vet. Sci.* 13(6): 1169-1179. DOI | <https://dx.doi.org/10.17582/journal.aavs/2025/13.6.1169.1179>.
- Bryden, W. L., Li, X., Ruhnke, I., Zhang, D., & Shini, S. (2021). Nutrition, feeding and laying hen welfare. *Animal Production Science*, 61(10), 893-914.
- Djulardi, A., Triani, H. D., & Yuniza, A. (2024). Study of avocado seed and banana peel processing as corn element substitution in Japanese quail (*Coturnix-Coturnix Japonica*) ration.

- Duncan, D.B. 1955. Multiple Rang and Multiple F-test. *Biometrics*. 11: 4-42.
- Emami, N. K., Jung, U., Voy, B., & Dridi, S. (2020). Radical response: effects of heat stress-induced oxidative stress on lipid metabolism in the avian liver. *Antioxidants*, 10(1), 35.
- Farida, N., G. Abdul and R.L. Sri,)2009(. Pengaruh ekstrak kulit buah rambutan terhadap kadar kolesterol total dan trigliserid pada tikus yang diberi diet tinggi kalori. Skripsi. Universitas Negeri Malang. Indonesia.
- Haryanto, A., Miharja, K., & Wijayanti, N. (2016). Effects of banana peel meal on the feed conversion ratio and blood lipid profile of broiler chickens. *International Journal of Poultry Science*, 15(1), 27-34.
- Hikal, W. M., Said-Al Ahl, H. A., Bratovcic, A., Tkachenko, K. G., Sharifi-Rad, J., Kačániová, M., & Atanassova, M. (2022). Banana peels: A waste treasure for human being. *Evidence-Based Complementary and Alternative Medicine*, 2022(1), 7616452.
- Ibrahim, H. M., & Salem, F. M. A. (2013). Effect of adding lemongrass and lime peel extracts on chicken patties quality. 9:5035-5047.
- Islam, M. R., Kamal, M. M., Kabir, M. R., Hasan, M. M., Haque, A. R., & Hasan, S. K. (2023). Phenolic compounds and antioxidants activity of banana peel extracts: Testing and optimization of enzyme-assisted conditions. *Measurement: Food*, 10, 100085.
- Jomova, K., Raptova, R., Alomar, S. Y., Alwasel, S. H., Nepovimova, E., Kuca, K., & Valko, M. (2023). Reactive oxygen species, toxicity, oxidative stress, and antioxidants: chronic diseases and aging. *Archives of toxicology*, 97(10), 2499-2574.
- Kanbur, G., Göçmen, R., & Cufadar, Y. (2023). Effect of dietary banana leaves (*Musa acuminata*) with multienzyme complex supplementation on intestinal content, serum biochemicals, egg production, and egg quality in laying quail. *Livestock Science*, 277, 105249.
- Kpodo, K. R., & Proszkowiec-Weglarz, M. (2023). Physiological effects of in ovo delivery of bioactive substances in broiler chickens. *Frontiers in Veterinary Science*, 10, 1124007.
- Leke, J. R., Wantasen, E., Siahaan, R., & Sompie, F. (2022a). The nutritional content of egg and blood's lipid profile of layer fed by Kepok banana meal (*Musa paradisiaca* L.) as feed supplement.
- Leke, J. R., Wantasen, E., Siahaan, R., Sompie, F., Kaunang, C., Widjastuti, T., & Natsir, M. H. (2022b). The effect of Kepok Banana (*Musa Paradisiaca* L.) on immunoglobulin, vitamins, and cholesterol content of eggs in laying hens. *Journal of World's Poultry Research*, 12(1), 46-51.
- Lopes, S., Borges, C. V., de Sousa Cardoso, S. M., de Almeida Pereira da Rocha, M. F., & Maraschin, M. (2020). Banana (*Musa* spp.) as a source of bioactive compounds for health promotion. *Handbook of banana production, postharvest science, processing technology, and nutrition*, 227-244.
- Oliveira, G. D. S., McManus, C., Salgado, C. B., Pires, P. G. D. S., de Figueiredo Sousa, H. A., da Silva, E. R., & Dos Santos, V. M. (2023). Antimicrobial coating based on Tahiti lemon essential oil and green banana flour to preserve the internal quality of quail eggs. *Animals*, 13(13), 2123.
- Salas, J., & FONTANILLA, I. (2025). Feeding value of amino acids and minerals-enriched banana (*Musa sapienta*) peel and spent sweet potato (*Ipomea batatas*) meal-based diets on the laying performance of japanese quail (*Coturnix coturnix Japonica*). *Journal of Animal Science and Veterinary Medicine*, 10(1), 91-96.
- Salman, K.A.A, M.K.I. Al-Saeedi and H.H. Al-Jebory. 2025. Effect of adding manganese sulfate for diet on the hormonal and histological response of aged roosters exposed to heat stress. *Kufa Journal For Agricultural Sciences – 2025:17(1) : 131-141*.
- Salman, K.A.A., Al-Saeedi, M.K.I., Al-Jebory, H.H. and Al-Jebory, R.F., 2024. Effect of neem (*Azadirachta indica*) leaf powder supplementation on some blood parameters in broiler chickens exposed to heat stress. *Punjab Univ. J. Zool.*, 39(2): 177-183. <https://dx.doi.org/10.17582/journal.pujz/2024/39.2.177.183>.
- SAS, 2012. Statistical Analysis System, User's Guide. Statistical. Version 9.1th ed. SAS. Inst. Inc. Cary. N.C. USA.
- Scott, G. J. (2021). A review of root, tuber and banana crops in developing countries: past, present and future. *International Journal of Food Science and Technology*, 56(3), 1093-1114.
- Şengül, A. Y., Şengül, T., Çelik, Ş., İnci, H., Şengül, G., Dörtbudak, M. B., Terzioğlu, E. E., & Daş, A. (2025). The effects of using different levels of banana (*Musa acuminata*) peel powder on productivity performance, egg quality, blood parameters, fatty acid profile, and intestinal histopathology of laying quails. *Poultry science*, 104(10), 105331. <https://doi.org/10.1016/j.psj.2025.105331>

- Shumye, M., Molla, M., Awoke, T., & Dagnew, Y. (2022). Effect of banana peels as a substitute for white maize grain on laying performances and egg quality of Bovans Brown chickens. *Cogent Food & Agriculture*, 8(1), 2116803.
- Sugiharto, S. (2023). The effect of using fruit peel on broiler growth and health. *Veterinary World*, 16(5), 987.
- Sugiharto, S., Yudiarti, T., Isroli, I., Widiastuti, E., Wahyuni, H. I., & Sartono, T. A. (2020). Growth performance, haematological responses, intestinal microbiology and carcass traits of broiler chickens fed finisher diets containing two-stage fermented banana peel meal. *Tropical animal health and production*, 52(3), 1425-1433.
- Surai, P. F., Kochish, I. I., Fisinin, V. I., & Kidd, M. T. (2019). Antioxidant defence systems and oxidative stress in poultry biology: An update. *Antioxidants*, 8(7), 235.
- Tian; W.X., X.F. Ma, S.Y. Zhang, Y.H. Sun and B.H. Li, 2011. Fatty acid synthesis inhibitor from plants and their potential application in the prevention of metabolic syndrome. *Clin. Oncol. Cancer. Res.*, 8: 1-9
- Vlaicu, P. A., & Untea, A. E. (2024). Application of Natural Antioxidants from Fruits Waste for Improving Egg Quality Characteristics. *Applied Sciences*, 14(22), 10437. <https://doi.org/10.3390/app142210437>.
- Waraczewski, R., & Sołowiej, B. G. (2024). Potential valorization of banana production waste in developing countries: bio-engineering aspects. *Fibers*, 12(9), 72.