



e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE



Effect of different postharvest treatments on shelf life and quality of banana (*Musa* spp.) at Charikot, Dolakha, Nepal

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ARTICLE HISTORY

Received: 14 March 2025

Revised received: 02 May 2025

Accepted: 11 May 2025

Keywords

Banana

Calcium chloride

Post-harvest losses

Potassium permanganate

ABSTRACT

This experiment was carried out in the laboratory of Rural Development Tuki Association, Charikot, Dolakha, Nepal to study the shelf life and physio-chemical parameters of banana. The design of the experiment was completely randomized design (CRD) with 7 treatments and 3 replications with 7 destructive and 5 non-destructive samples. Samples were kept under different packaging materials. The treatments included as control, unperforated bag, perforated bag, unperforated bag with KMnO_4 , perforated bag with KMnO_4 , unperforated bag treated with CaCl_2 , perforated bag treated with CaCl_2 . The data were collected from the destructive and non-destructive sample in 2 days' interval and MS-EXCEL and R-STUDIO was used for the data analysis. The highest physiological weight loss of banana was in control (23.33%) and lowest in unperforated polybag (0.66%), unperforated polybag with CaCl_2 (0.73%), unperforated polybag with KMnO_4 (1.53%) in 12 days after treatment. The highest shelf life of banana was in unperforated bags with KMnO_4 (19 days) while the lowest shelf life was observed in control (9 days). The highest pulp to peel ratio was observed in control (2.23) while the lowest pulp to peel ratio was in unperforated bags with KMnO_4 (1.46). The pH showed insignificant result and similarly TSS showed insignificant result till 6 DAT while control showed highest (14) and lowest was found in unperforated polybag with KMnO_4 (9.33) and unperforated polybag (9.33) at 12 days after treatment. Thus, unperforated polybag with KMnO_4 could be used to enhance post-harvest life of banana.

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Citation of this article: Devkota, R., & Khatri, N. (2025). Effect of different postharvest treatments on shelf life and quality of banana (*Musa* spp.) at Charikot, Dolakha, Nepal. *Archives of Agriculture and Environmental Science*, 10(2), 279-284, <https://dx.doi.org/10.26832/24566632.2025.1002013>

INTRODUCTION

Banana fruit of the genus *Musa*, of the family Musaceae, one of the most important fruit crops of the world. The banana is grown in the tropics and is widely consumed due to its flavor, nutritional value, and availability throughout the year. The fruit is variable in size, color, and firmness and is elongated and curved, with soft flesh rich in starch covered with a rind, which may have a variety of colors when ripe. The area under banana cultivation is 24,286 ha, production being 404,670 Mt and productivity being 16.66 Mt/ha in Nepal and the area under banana cultivation is 37 ha, production being 274 Mt and productivity being 7.42 Mt/ha in Dolakha (MoALD, 2024).

Banana being a climacteric fruit undergoes rapid ripening by an autocatalytic climacteric burst of gaseous hormone ethylene. Rapid textural change is followed by excessive tissue softening and subsequent spoilage of banana during late-ripen phase leads to heavy loss of the crop each year and its post-harvest losses range from 25-50% (Ghimire *et al.*, 2021). Major causes of post-harvest losses in fruits and vegetables are improper stage of maturity, direct packing and shipping without removal of field heat, improper packing and insufficient grading and sorting, poor transportation and handling and poor storage facilities. However, the majority of losses occur during transportation from yard to collection center and thereafter to the wholesale market and retail outlets (Adhikari & G.C., 2021).

Demand of banana consumption is increasing day by day due to its high caloric and nutritional value, but non-availability of adequate postharvest storage facilities has posed a great threat to the commercial cultivation of banana. In Nepal, banana is widely cultivated both in tropical and sub-tropical regions (Dhakal et al., 2021). Reducing postharvest losses is very important; ensuring that sufficient food, both in quantity and in quality is available to every inhabitant in our planet (Sah et al., 2023). Thus, in case of banana production postharvest losses being major concern this action research might bring some positive impact in the minimization of losses by following good post-harvest handling practices ensuring safety. The physical, biochemical and overall characteristics will also be retained through this. The specific objectives of this study were to study the physio-chemical changes affected by chemicals and packaging in banana, to assess the effect of treatments on shelf life of banana and to identify the most suitable postharvest treatments to maximize the quality and shelf life of banana.

MATERIALS AND METHODS

Experimental site

Study was conducted in lab of Rural Development Tuki Association. It was situated at latitude 27.669518 °N and longitude 86.051006 °E (Figure 1). The temperature and humidity of the lab was recorded throughout the experiment by a thermo-hygrometer (Figure 2).

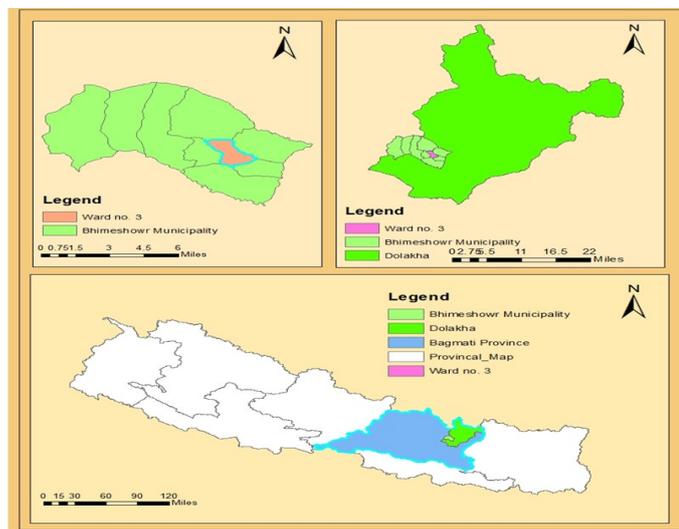


Figure 1. Map of study area at Charikot, Dolakha, Nepal.

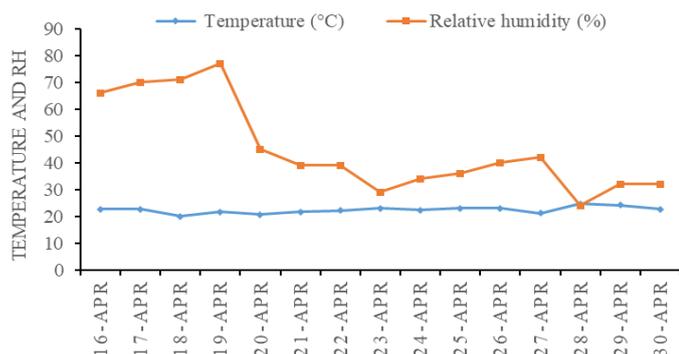


Figure 2. Temperature and relative humidity of laboratory during the experiment.

Experimental details

Banana fruits were collected from the farmer field of tamakoshi which comes under ADO, Dolakha, Nepal. Fruits were harvested at mature green stage. The physiological mature fruits were harvested and carefully collected in the plastic bags. The harvest fruits were kept in the cool and dry place to remove the field heat. The fruits of uniform size and color was selected for the experiment treatment. The fruits were wiped with tissue paper to remove the dirt and inert matters. The experiment was conducted in completely randomized design (CRD) with 7 treatments and each treatment was replicated 3 times. Total 12 fruits were used for each replication; 5 fruits were used as a non-destructive sample and 7 fruits was used as a destructive sample. The sample were selected using simple random sampling. The total number of required samples was 252 fingers. 6 perforations were made in perforated bag. 2% CaCl₂ solution was prepared and samples were dipped for about 15 minutes (Sahay et al., 2015). 2 g of cotton ball was soaked in 2.5 ml of KMnO₄ solution and 4 perforations were made in polyethylene bag in which soaked cotton ball was placed and stucked to the wall of packaging materials and samples were kept and sealed (Dhakal et al., 2021). The details of treatments used in the study are as follows:

Treatment details

- T1: Control
- T2: Bananas in unperforated bag
- T3: Bananas in perforated bag
- T4: Bananas in unperforated bag containing KMnO₄
- T5: Bananas in perforated bag containing KMnO₄
- T6: Bananas in unperforated bag treated with CaCl₂
- T7: Bananas in perforated bag treated with CaCl₂

Observations

Physiological Loss in Weight (PLW): The difference in the initial weight and final weight at subsequent 2day interval was recorded and calculated by using formula:

$$PLW = \{(IW-FW)/IW\} * 100\%$$

Where, PLW= Physiological Loss in Weight, IW= Initial weight, FW= Final weight.

Shelf life: Shelf life was based on the development of discoloration i.e. blackened skin, off-flavor, fungal attack, skin shriveling. End of shelf life can be visualized when more than 50% fruit become unfit.

Pulp to peel ratio: The change in weight of pulp and of peel was taken in 2 days interval and its ratio was calculated as pulp weight/ peel weight.

Total Soluble Solid (TSS): Banana fruit from each replication of destructive sample was taken and peel of the banana was removed and flesh was grinded and sieved as well as squeezed in

muslin cloth and the extracted juice was placed in the prism surface and reading was noted with the help of hand-held refractometer for total soluble solids ($^{\circ}$ Brix).

pH: The pH meter probe was dipped in 5 ml juice extracted from the sample and reading was taken.

Statistical analysis

Data was systematically arranged on the basis of various observed parameters. Different statistical tools as R-studio and EXCEL and MS- Word 2016 was used for the analysis of variance and other data analysis. The data was analyzed and findings was discussed and related with available literature. Graphs and tables was constructed by using MS-Excel.

RESULTS AND DISCUSSION

Physiological loss in weight

Physiological loss in weight is the ratio of difference between initial and final weight to the initial weight. Variation in treatments were very highly significant during all days of storage (Table 1). The maximum weight loss was at control at 3rd (7.66), 6th (13.00), 9th (18.00) and 12th (23.33) days after treatment. The minimum weight loss was found at unperforated polybag (0.052) followed by unperforated polybag treated with CaCl₂ (0.42) at 3rd day after treatment. Similarly, unperforated polybag (0.30), unperforated polybag with treated CaCl₂ (0.43) at 6th days after treatment. At 9th day unperforated polybag with KMnO₄ (1.53) also showed low weight loss along with unperforated polybag (0.60), unperforated polybag with treated CaCl₂ (0.83) which are significantly at par. The insignificant difference in unperforated polybag with KMnO₄ (1.53), unperforated polybag (0.66), unperforated polybag with treated CaCl₂ (0.73) days were noticed that showed low weight loss at 12 DAT. The physiological weight loss was found to be highest in control. Fruit

transpiration is responsible for the fruit cumulative weight loss during storage and the findings were similar to the (Elbagoury et al., 2021). The similar finding of low weight loss in unperforated bags with KMnO₄ and high in control is also the findings of (Dhakal et al., 2021). This may be due to delay in fruit ripening in presence of KMnO₄ due to which tissue permeability would be decreased and reduction in weight loss in fruits. Ca is known to enhance tissue membrane integrity, firmness and cell turgor which extends the storage life of fresh fruits and vegetables. Ca is known to reduce physiological disorders and delays membrane lipid catabolism (Elbagoury et al., 2021). Similarly, CaCl₂ positive effect is found in decrement of weight loss which is also reflected in (Mulagund et al., 2015). In the same way, result is similar with (Sahay et al., 2015). The result is also similar with (Zewter et al., 2012).

Shelf life

The shelf life for each treatment in this study was determined to be statistically very highly significant (Table 2 and Figure 3), showing variations in performance during storage period. The highest shelf life was in unperforated bags with KMnO₄ (19 days) followed by unperforated bags with CaCl₂ (14.00 days) and perforated polybag with KMnO₄ (14.67 days). The lowest shelf life was observed in control (9.00 days), followed by bananas in unperforated polybags (9.33 days). Modified atmosphere packaging with ethylene scavenging compound KMnO₄ showed prolonged shelf life as compared to control treatment (Akter et al., 2013). The delay in fruit ripening and extension of shelf life due to KMnO₄ were reflected in (Elzubeir et al., 2017). The result gets support from the findings of (Akter et al., 2013) and also in agreement with the article of (Zomo et al., 2014; Dhakal et al., 2021). This may be due to decrease in respiration rate leading to delay in onset of climacteric peak and KMnO₄ ethylene absorbing nature decreasing in chlorophyllase activity.

Table 1. Effect of different post-harvest treatments on physiological loss in weight of banana.

| Treatments | Physiological loss in weight (Days) | | | |
|---|-------------------------------------|--------------------|--------------------|--------------------|
| | 3DAT | 6DAT | 9DAT | 12DAT |
| Control | 7.66 ^a | 13.00 ^a | 18.00 ^a | 23.33 ^a |
| Unperforated polybag | 0.052 ^d | 0.30 ^d | 0.60 ^d | 0.66 ^e |
| Perforated polybag | 1.03 ^c | 2.16 ^b | 5.33 ^c | 5.66 ^c |
| Unperforated polybag with KMnO ₄ | 1.20 ^c | 1.33 ^c | 1.53 ^d | 1.53 ^e |
| Perforated polybag with KMnO ₄ | 1.83 ^b | 2.33 ^b | 7.67 ^b | 7.67 ^b |
| Unperforated polybag with CaCl ₂ | 0.42 ^d | 0.43 ^d | 0.83 ^d | 0.73 ^e |
| Perforated polybag with CaCl ₂ | 1.20 ^c | 2.67 ^b | 5.33 ^c | 3.90 ^d |
| SE _M (±) | 0.17 | 0.26 | 0.58 | 0.50 |
| LSD (0.05) | 0.52 | 0.80 | 1.77 | 1.50 |
| F probability | <0.001 | <0.001 | <0.001 | <0.001 |
| CV(%) | 15.00 | 14.4 | 18.00 | 14.16 |
| Grand mean | 1.93 | 3.17 | 5.61 | 6.07 |

Note: Treatment means separated by DMRT and values with the same letter(s) are non-significant at the 5% level of significance; LSD: Least Significant Difference; SE_M: Standard error of the mean deviation; CV: Coefficient of Variance.

Table 2. Effect of different post-harvest treatments on shelf life of banana.

| Treatments | Shelf life (days) |
|---|---------------------|
| Control | 9.00 ^d |
| Unperforated polybag | 9.33 ^{cd} |
| Perforated polybag | 11.00 ^c |
| Unperforated polybag with KMnO ₄ | 19.00 ^a |
| Perforated polybag with KMnO ₄ | 14.67 ^b |
| Unperforated polybag treated with CaCl ₂ | 14.00 ^b |
| Perforated polybag treated with CaCl ₂ | 13.00 ^{bc} |
| SE _M (±) | 0.563 |
| LSD(0.05) | 1.70 |
| F probability | <0.001 |
| CV(%) | 7.58 |
| Grand mean | 12.85 |

Note: Treatment means separated by DMRT and values with the same letter(s) are non-significant at the 5% level of significance; LSD: Least Significant Difference; SE_M: Standard error of the mean deviation; CV: Coefficient of Variance.

Table 3. Effect of different post-harvest treatments on pulp to peel ratio of banana.

| Treatments | Pulp to peel ratio | | | |
|---|---------------------|--------------------|-------------------|--------------------|
| | 3DAT | 6DAT | 9DAT | 12DAT |
| Control | 1.96 ^a | 1.90 ^a | 1.93 ^a | 2.23 ^a |
| Unperforated polybag | 1.93 ^{ab} | 1.80 ^a | 1.53 ^b | 1.73 ^{bc} |
| Perforated polybag | 1.80 ^{abc} | 1.70 ^{ab} | 1.50 ^b | 1.80 ^{bc} |
| Unperforated polybag with KMnO ₄ | 1.20 ^d | 1.23 ^d | 1.46 ^b | 1.46 ^d |
| Perforated polybag with KMnO ₄ | 1.67 ^{bc} | 1.36 ^{cd} | 1.53 ^b | 1.60 ^{cd} |
| Unperforated polybag treated with CaCl ₂ | 1.73 ^{abc} | 1.67 ^{ab} | 1.53 ^b | 1.60 ^{cd} |
| Perforated polybag treated with CaCl ₂ | 1.57 ^c | 1.53 ^{bc} | 1.80 ^a | 1.86 ^b |
| SE _M (±) | 0.086 | 0.076 | 0.077 | 0.066 |
| LSD (0.05) F probability | 0.262<0.001 | 0.232<0.001 | 0.235<0.01 | 0.200<0.001 |
| CV(%) | 8.82 | 8.29 | 7.33 | 6.57 |
| Grand mean | 1.69 | 1.60 | 1.61 | 1.75 |

Note: Treatment means separated by DMRT and values with the same letter(s) are non-significant at the 5% level of significance; LSD: Least Significant Difference; SE_M: Standard error of the mean deviation; CV: Coefficient of Variance.

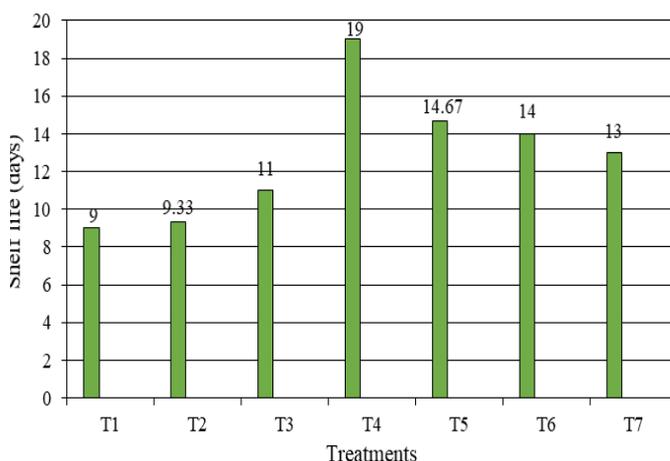
Table 4. Effect of different post-harvest treatments on Total Soluble Solids (TSS) of banana.

| Treatments | TSS (°Brix) | | | |
|---|-------------|------|---------------------|---------------------|
| | 3DAT | 6DAT | 9DAT | 12DAT |
| Control | 3.66 | 5.67 | 12.00 ^a | 14.00 ^a |
| Unperforated polybag | 4.33 | 4.67 | 9.00 ^{bc} | 9.33 ^c |
| Perforated polybag | 5.33 | 4.67 | 9.33 ^{bc} | 10.67 ^{bc} |
| Unperforated polybag with KMnO ₄ | 4.67 | 5.67 | 7.67 ^c | 9.33 ^c |
| Perforated polybag with KMnO ₄ | 4.00 | 5.00 | 10.33 ^{ab} | 11.67 ^b |
| Unperforated polybag treated with CaCl ₂ | 3.67 | 4.66 | 9.67 ^{abc} | 10.00 ^{bc} |
| Perforated polybag treated with CaCl ₂ | 5.66 | 4.33 | 7.67 ^c | 10.67 ^{bc} |
| SE _M (±) | 0.53 | 0.48 | 0.75 | 0.61 |
| LSD(0.05) F probability | NS | NS | 2.26<0.005 | 1.83<0.01 |
| CV(%) | | | 13.76 | 9.68 |
| Grand mean | 4.47 | 4.95 | 9.38 | 10.80 |

Note: Treatment means separated by DMRT and values with the same letter(s) are non-significant at the 5% level of significance; LSD: Least Significant Difference; SE_M: Standard error of the mean deviation; CV: Coefficient of Variance.

Pulp to peel ratio

The treatments were found to be statistically very highly significant during storage period (Table 3). The highest pulp to peel ratio was observed in control (1.96) while the lowest pulp to peel ratio was in unperforated bags with KMnO₄(1.20) at 3 DAT which remained same till 6th DAT while in 9 DAT highest was in control (1.93) and in perforated bag with CaCl₂(1.80). In 12th DAT control had highest ratio (2.23) and lowest in KMnO₄(1.46).

**Figure 3.** Shelf life of banana at different treatments.

Similar result of low pulp to peel ratio was the findings of (Al Muzahid *et al.*, 2021). The increased ratio during storage may be related to the change in sugar concentration in the pulp compared to the peel thus contributing to different change in osmotic pressure. Water might be lost from the peel of banana both by transpiration and osmosis due to which the peel weight was reduced and pulp to peel ratio increases (Al Muzahid *et al.*, 2021).

Table 5. Effect of different post-harvest treatments on pH of banana.

| Treatments | pH | | | |
|---|-------|-------|-------|-------|
| | 3DAT | 6DAT | 9DAT | 12DAT |
| Control | 5.67 | 5.40 | 5.20 | 4.43 |
| Unperforated polybag | 5.50 | 5.50 | 4.77 | 4.60 |
| Perforated polybag | 5.63 | 5.63 | 4.53 | 4.33 |
| Unperforated polybag with KMnO ₄ | 5.93 | 5.93 | 4.73 | 4.23 |
| Perforated polybag with KMnO ₄ | 5.60 | 5.17 | 4.33 | 4.87 |
| Unperforated polybag treated with CaCl ₂ | 5.63 | 5.63 | 4.47 | 4.57 |
| Perforated polybag treated with CaCl ₂ | 5.70 | 5.70 | 4.93 | 4.77 |
| SE _M (±) | 0.135 | 0.308 | 0.318 | 0.140 |
| LSD=(0.05) F probability | NS | NS | NS | NS |
| CV,% | | | | |
| Grand mean | 5.67 | 5.30 | 4.77 | 4.35 |

Note: Treatment means separated by DMRT and values with the same letter(s) are non-significant at the 5% level of significance; LSD: Least Significant Difference; SE_M: Standard error of the mean deviation; CV: Coefficient of Variance.

Total Soluble Solid (TSS)

Treatments were found to be statistically insignificant at 3rd and 6th days after treatment (Table 4). The highest TSS was at control (12.00), (14.00) at 9 and 12 DAT respectively. The lowest TSS was at unperforated polybag with KMnO₄(7.67) at 9th day of treatment. Unperforated polybag with KMnO₄(9.33) and unperforated polybag (9.33) showed low TSS at 12DAT. The highest TSS was at control while low in unperforated polybag and unperforated polybag with KMnO₄. Finding is similar to that of Dhakal et al. (2021) and Al Muzahid et al. (2021) who also reported the lowest TSS in banana.

pH

The table indicated insignificant difference of different post-harvest treatment during storage period in 3, 6, 9 and 12 DAT (Table 5). The pH was recorded as 5.67, 5.30, 4.77, and 4.37 at 3, 6, 9, and 12 DAT. It also affected the shelf life of bananas under different treatment conditions.. The results are in agreement with Al Muzahid et al. (2021) who reported the effects of different stages of maturity and postharvest treatments on the extension of shelf life and quality of banana and reported that KMnO₄ treatment can enhance the self-life of banana.

Conclusion

This study reveals differences in the treatments where the effect of various treatments was analyzed. As per the objectives various parameters were analyzed and according to the findings, high physiological weight loss was in control and lowest in unperforated polybag, unperforated polybag with CaCl₂, unperforated polybag with KMnO₄. Shelf life was found maximum in unperforated with KMnO₄ while minimum in control. The increment in pulp to peel ratio was at highest in control and low in unperforated polybag with KMnO₄. TSS showed insignificant result at 3rd and 6th DAT while TSS was found to be highest under control and lowest in unperforated polybag with KMnO₄ and unperforated polybag. The parameter pH showed insignificant result. Appropriate treatment could be used for prolonging shelf life by judging parameters. Thus, unperforated polybag with KMnO₄ could be used to enhance post-harvest life.

ACKNOWLEDGMENTS

The authors are thankful to Prime Minister Agriculture Modernization Project of Government of Nepal, Agriculture and Forestry University, Nepal, College of Natural Resources Management, Kapilakot, Sindhuli, Agriculture Service Centre, Dolakha, Agriculture Development Office, Ramechhap for facilitating the study.

DECLARATIONS

Author contribution statement

Conceptualization: R.D and G.L; Methodology: R.D.; Software and validation: R.D. and N.K.; Formal analysis and investigation: R.D., G.L and N.K.; Resources: R.D.; Data curation: R.D.; Writing—original draft preparation: R.D.; Writing—review and editing: R.D.; Visualization: N.K. and G.L; Supervision: G.L.; Project administration: R.D. and N.K. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.

Consent for publication: All co-authors gave their consent to publish this paper in AAES.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: No supplementary data is available for the paper.

Funding statement: No external funding is available for this study.

Additional information: No additional information is available for this paper.

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