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EVALUATION OF TRADITIONAL STORAGE MATERIALS FOR IMPROVING POST-HARVEST SHELF-LIFE AND QUALITY OF TURMERIC (*Curcuma longa*)

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ABSTRACT

Loss in post-harvest quality and shorter shelf-life of turmeric (*Curcuma longa*) rhizomes in Nepal are substantial due to a lack of proper storage practices, affecting both marketable rhizome and seed rhizome quality. To find an appropriate solution of this problem, the research was conducted using seven different storage materials- T1: Straw + sand + sawdust, T2: Sand + sawdust, T3: Straw + sawdust, T4: Sand, T5: Sawdust, T6: Straw, and T7: Control- over 84 days in the Eastern Terai region of Nepal. This research was conducted in a single-factorial Randomized Complete Block Design (RCBD) replicated thrice. Observations for physiological weight loss, sprouting, sprout length, insect incidence, rotting, and shrinkage percentage were recorded at 14-day intervals during the research. Results revealed that all storage materials significantly reduced post-harvest losses compared to the control (without storage material), with straw consistently outperforming all other treatments. Use of straw-based storage material significantly minimized physiological weight loss (19.6%), caused the shortest sprout length (1.31 cm), reduced shrinkage percentage (6.6%), minimal insect incidence (0.4%) and rotting (0.7%). This might be likely due to its insulating properties, moisture retention and ability to create a microenvironment which is unfavorable for pests and pathogens and favorable for moisture retention. A combination of straw with sand or sawdust also resulted in better results than the control, but straw alone consistently outperformed. These findings highlight straw as a locally available, environmentally friendly and cost-effective storage material is offering a practical and scientific strategy to enhance the shelf-life and postharvest quality of turmeric rhizome.

Key words: *Physiological weight loss, sprouting, shrinkage, post-harvest*

INTRODUCTION

Turmeric (*Curcuma longa*) is a rhizomatous spice belonging to the Zingiberaceae family, which is nutritionally rich, comprising approximately 13.1% moisture, 6.3% protein, 5.1% fat, 69.4% carbohydrates, 3.5% minerals, and approximately 5.8% volatile essential oils. Additionally, it is rich with 3–4% of characteristic yellow pigmentation (Chattopadhyay et al., 2004; Li et al., 2011). Due to its bioactive compounds and therapeutic potential, it is commonly used as a culinary spice and as a medicinal agent in Ayurveda and Chinese medicine (Chandran & Goel, 2012). Beyond its medicinal value, it is a key ingredient in cosmetic formulation, where it is employed for complexion enhancement, acne management, and overall skin health improvement (Aggarwal et al., 2013). It is also used as a natural dye due to its vibrant yellow colour (Rafieian-Kopaei et al., 2014). Processed and value-added products of turmeric, such as dried rhizome, turmeric powder, curry powder, curcumin, oleoresins, essential oils, etc, are also common (Domestua, 2019). In Nepal, it is an integral part of the Nepalese kitchen used for taste, colour and nutritional value (Khanal et al., 2021). Reflecting its cultural and economic importance, 9022 ha of land, with a productivity of 10.02 tonnes per ha and a production of 90,428 tonnes of turmeric rhizomes, have been recorded in the fiscal year 2022/23 (MoALD, 2024).

Post-harvest management of turmeric is critical for enhancing shelf life and quality of rhizomes (Kahramanoğlu, 2017). Among those practices, the appropriate storage method with storage material plays a pivotal role in minimizing postharvest loss, increasing shelf life and maintaining the quality of turmeric (Bunsa, 2019). In Nepal, pit storage- one of the traditional and resource-efficient methods- is most commonly used for storing turmeric rhizomes after harvesting (Rai, 2015). It is mainly adopted by farmers to maintain quality and increase shelf life for year-round distribution, and preserve planting material for the subsequent cropping cycle. The turmeric rhizomes should be stored in such a practical and cost-effective way which preserves nutritional quality and prevents spoilage, flavour loss and extends shelf-life (Mukrimaa et al., 2016).

In Nepal, improper storage practices are causing huge postharvest loss of turmeric. Farmers store harvest rhizomes in a large heap, causing deterioration and quality loss (Kumar et al., 2015). In Nepal, farmers are devoid of practically suitable and scientifically guided storage practices. This is causing huge loss of turmeric rhizomes, quantitatively and qualitatively (Bhattarai, 2018). Similarly, it is difficult to get turmeric rhizomes (seed) during planting time and preserving them at the farmers' level is challenging and critical and is of pivotal importance for cultivation and successful crop establishment. Generally, harvested turmeric rhizomes are retained by farmers for seed purposes and stored for typically 80 to 120 days, i.e., till April. During this period, substantial losses occur due to weight loss, decay, insects and pests (Dodamani et al., 2017). Despite the widespread use of pit storage systems in rural areas, scientific evidence regarding the efficacy of various materials used within these pits for maintaining rhizome quality remains limited.

Pit storage is widely practised across Nepal for the storage of turmeric rhizome, principally for seed purposes and to some extent, for processing purposes, with the goal to enhance the quality and increase the post-harvest life of stored rhizomes. Despite its popularity among Nepalese farmers, scientific evaluation of the effectiveness of various storage materials - such as straw, sawdust, soil within the pit systems remains scarce (Ghimire et al., 2020). Consequently, farmers rely on traditional knowledge and inconsistent practices, often leading to significant loss of rhizomes. Furthermore, evidence-based recommendations, along with a lack of region-specific knowledge, hinder the practices adopted by farmers for rhizome preservation.

This study, therefore, aims to find the performance of turmeric rhizomes under various materials in pit storage in the inner Terai conditions of Nepal. These findings are expected to provide guidance and methods to farmers for reducing post-harvest losses, maintaining proper seed quality and promoting sustainable production of turmeric to smallholder farmers of Nepal.

MATERIALS AND METHODS

The study was conducted in Udayapur district of Nepal, which is located in the Eastern Inner Terai region of Nepal. The experimental site was situated at an elevation of 610 meters above sea level, with GPS coordinates of 86.6410°E and 26.7807° N.

The experiment was designed on a Randomized Complete Block Design (RCBD) with three replications. Seven storage materials, including control, were used for the experiment, which was replicated three times. Each treatment/storage materials were placed in an individual pit having a size of 40 cm × 50 cm with a depth of 50 cm. The storage materials were assigned in each pit by complete randomization, using a lottery method within each replication.

Treatment Details:

T1: Half bundle of paddy straw, 0.5 kg of sawdust, and 2 kg of sand

T2: 3 kg of sand and 1 kg of sawdust

T3: Bundle of straw and 1 kg of sawdust

T4: 5 kg of sand

T5: Sawdust

T6: 2 bundles of straw

T7: Control (No storage material was used)

Observations were recorded at 14-day intervals for physiological weight loss (%), insect incidence (%), number of sprouts and their length (cm), rooting (%), and shrinkage percentage. The following formulas were used to calculate the respective parameters.

1. Physiological Weight Loss

Physiological weight loss (%) = $\frac{Wi-Wt}{Wi}100$

where Wi = initial rhizome weight and Wt is the weight of turmeric at the designed time (Pongener *et al.*, 2014).

2. Insect Incidence (%)

Insect incidence (%) = $\frac{Weight\ of\ turmeric\ rhizome\ infected\ by\ insects}{Total\ weight\ of\ rhizome} \times 100$

(Bisen *et al*., 2019)

3. Rotting (%)

Rotting (%) = $\frac{Weight\ of\ rotten\ rhizome}{Total\ weight\ of\ rhizome} \times 100$

4. Shrinkage (%)

Shrinkage (%) = $\frac{Weight\ of\ shrunk\ rhizome}{Total\ weight\ of\ rhizome} \times 100$

5. Number of Sprouts

The number of sprouts was counted during each observation and recorded.

6. Length of Sprouts

The length of sprouted rhizomes was measured using a measuring scale and recorded.

Data were initially entered and processed using Microsoft Excel 2016. These data were statistically analyzed in R software (Version 4.3.1). Analysis of variance (ANOVA) was employed to evaluate the effects, and mean separations were carried out using Duncan's Multiple Range Test (DMRT) at a 5% significance level ($p \leq 0.05$).

RESULTS AND DISCUSSION

Physiological weight loss of turmeric (%)

The analyzed data revealed that the physiological weight loss (%) of turmeric rhizome was significantly affected ($p < 0.05$) by different storage materials across all time intervals. At 14, 28, 42, 56, 70 and 84 days after storage using different materials in the pit, the lowest weight loss was consistently recorded in straw storage, i.e. 6%, 9.8%, 11.7%, 13.7%, 15.3% and 16.7% respectively. Meanwhile, control (use of no storage material) recorded the highest weight loss (8.5%, 11.7%, 14.3%, 16.5%, 18.2% and 19.6% on 14, 28, 42, 56, 70 and 84DAS, respectively). A mixture of straw, sand and sawdust as storage materials revealed the 2nd best storage materials to control physiological weight loss of turmeric after straw on 70 and 84 DAS, causing weight loss of 15.5% and 16.8% respectively. All storage materials and their combination shows better results than the control, with the straw being the most effective. Similar findings were reported by Nandini et al. (2014), who recorded minimal weight loss of turmeric rhizome under straw storage. The reason might be due to the insulating behaviour of straw, which buffers rhizomes from sudden cold during the night and provides the favourable environmental conditions for maintaining the weight (Jayaweera et al., 2024). Furthermore, the use of straw helps to maintain the moisture level, preventing excessive drying, which causes weight loss (Nandini et al., 2014; Jayaweera et al., 2024). Use of straw as storage material provides insulation against temperature fluctuations, which can accelerate weight loss (Nandini et al., 2014). Similarly, better performance of sand and sawdust on the weight loss of turmeric rhizome is due to the ability of both to create a microclimate that retains moisture (Kafiya et al., 2018).

Table 1: Effect of storage materials on the physiological weight loss of turmeric

Treatment	Physiological weight loss (%)					
	14DAS	28DAS	42DAS	56DAS	70DAS	84DAS
Straw +sand +sawdust (T1)	7.6±0.36^{b}	10.9±0.09^{bc}	12.7±0.21^{b}	14.2±0.20^{ab}	15.5±0.20^{a}	16.8±0.15^{a}
Sand +sawdust (T2)	8.4±0.67^{b}	11.5±0.23^{bc}	14±0.321^{c}	15.7±0.15^{c}	17.6±0.09^{d}	18.8±0.09^{d}
Straw +sawdust (T3)	7.5±0.22^{b}	10.6±0.24^{b}	12.9±0.15^{b}	14.5±0.15^{b}	16.3±0.12^{b}	17.6±0.12^{b}
Sand (T4)	8.3±0.23^{b}	11.5±0.44^{c}	13.6±0.19^{c}	15.3±0.15^{c}	16.9±0.09^{c}	18.2±0.09^{c}
Saw dust (T5)	8.03±0.35^{b}	11.5±0.15^{bc}	13.8±0.12^{c}	15.7±0.12^{c}	17.3±0.09^{d}	18.8±0.09^{d}
Straw (T6)	6.0±0.18^{a}	9.8±0.35^{a}	11.7±0.33^{a}	13.7±0.15^{a}	15.3±0.09^{a}	16.7±0.07^{a}
Control (T7)	8.5±0.18^{b}	11.7±0.21^{c}	14.3±0.15^{c}	16.5±0.23^{d}	18.2±0.20^{e}	19.6±0.22^{e}
LSD (0.05)	1.016	0.820	0.646	0.512	0.418	0.357
F- probability	**	**	***	***	***	***
CV (%)	7.36	4.166	2.729	1.908	1.404	1.11
Grand Mean	7.76	11.06	13.3	15.09	16.71	18.06

*Description: The same letter represents statistically at par while the symbols *, ** and *** represent significant difference at p value at 0.05, 0.01 and 0.001, respectively*

Length of Sprout (cm)

The analysed data demonstrated that different storage materials significantly ($p < 0.05$) influenced the sprouts' length (cm) across various storage intervals. Shortest sprout length was consistently recorded in straw, with values of 0.17 cm, 0.61 cm and 1.31 cm at 28DAS, 56DAS and 84DAS respectively, while the longest sprout length was recorded in both control and saw dust at 28DAS (0.4 cm), in control (without any materials in pit) at 56DAS (0.8 cm) and 84DAS (1.55 cm). At 28 and 56DAS, the sprout length in straw was statistically comparable ($p > 0.05$) to sprout length recorded in pits with storage material combination of straw+sand+sawdust, having lengths of 0.21 cm and 0.67 cm, respectively. At 84DAS, a combination of storage materials, straw+sand+sawdust (1.4 cm), straw+sawdust (1.4 cm) and sawdust (1.41 cm) revealed statistically similar ($p > 0.05$) sprout length as observed in straw.

Sprouting length in rhizomes might be affected by moisture and heat dynamics (Jayawickrama, 2016). Rhizomes' physiological ageing is accelerated by higher temperatures combined with lower humidity, and this can be exacerbated in straw storage as it regulates temperature and humidity levels, creating a microenvironment to suppress sprouting development (Nandini et al., 2014).

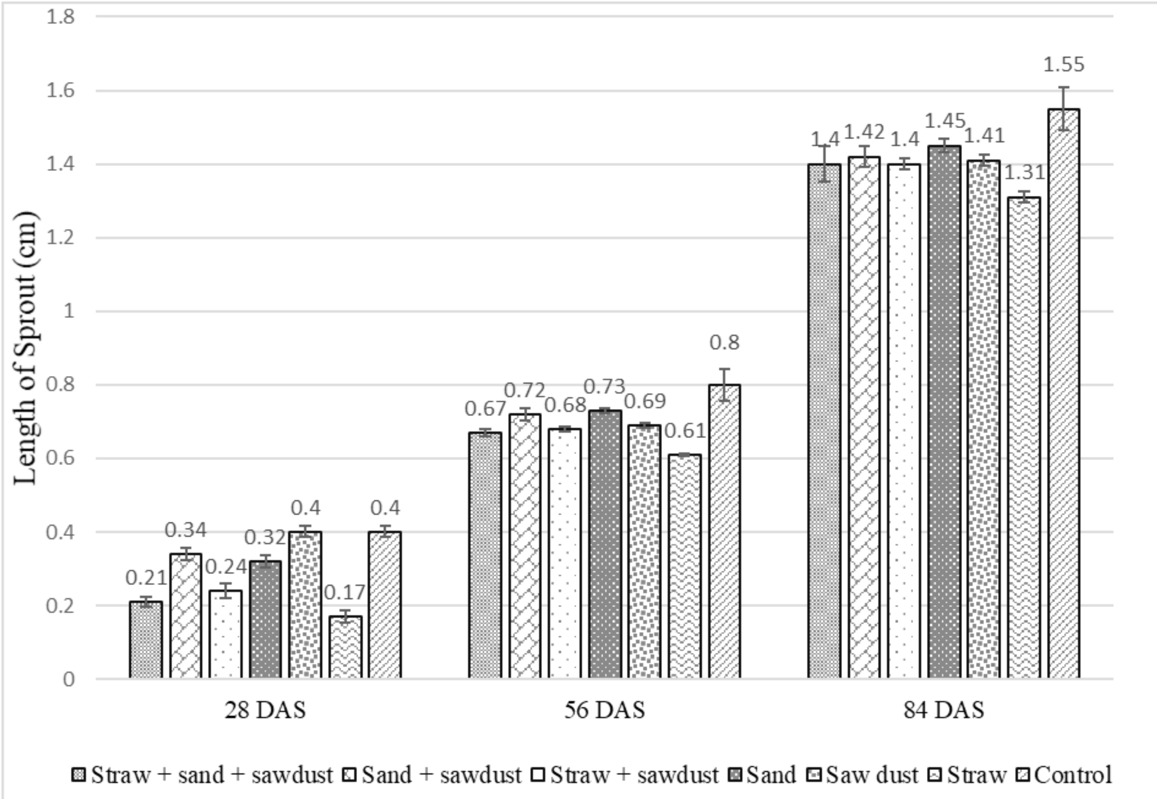

Figure 1: Effect of storage materials on the length of sprouts

Insect incidence (%) and rotting (%)

The following table 2 reveals that the use of different storage materials significantly ($p < 0.05$) affects the insect incidence percentage and rotting percentage. Straw-based storage significantly reduced insect, i.e., *Elytroteinus geophilus* infestation, recording 0.4%. In contrast, storage without using any storage material recorded substantially higher insect incidence (9.6%). This might be due to the characteristics of straw to regulate the moisture level (high relative humidity along with elevated temperature favours insect proliferation) below the threshold, which is required for insect proliferation and growth (Yasothai, 2019). Similarly, the air circulation facilitated by straw reduced moisture accumulation within the pits, causing repulsion of insects (Yewle et al., n.d.). Furthermore, the hygroscopic nature of straw maintains lower relative humidity in the pit, creating unfavourable conditions for insect growth and proliferation (Yasothai, 2019).

Similarly, the use of various storage materials in the pits revealed highly significant results ($p < 0.001$) in turmeric rotting percentage. Straw as storage material exhibited the best result, resulting in minimum rot incidence (0.7%) being statistically at par ($p > 0.05$) with the result of the combination of straw and sand (0.9%) and straw and sawdust (1.4%). In contrast, the highest level of rotting (4%) was recorded in storage without any storage materials. The reduced decay observed in straw-based treatment can be explained by the fact that it can regulate moisture, preventing excessive wet conditions and a stable environment, i.e. suitable environment for fungal proliferation (Sarathi et al., 2024). Similarly, it also maintains lower temperatures along with stable humidity, creating less favourable conditions for rotting (Zuniega & Esguerra, 2019; FAO, 2010). Furthermore, the fibrous structure of straw provides a physical barrier against fungal spores, which reduces the contamination from airborne pathogens (Jibat & Alo, 2023). By allowing adequate air circulation, straw prevents humidity buildup, which restricts fungal growth (Jayaweera et al., 2024). Along with this, it also maintains a stable temperature, further reducing the risk of rot (Yong, 2019).

Table 2: Effect of different storing materials on insect incidence (%) and rotting (%) of turmeric

Treatment	Insect incidence (%)	Rotting (%)
Straw +sand +sawdust	5.2±0.351[c]	0.9±0.145[ab]
Sand +sawdust	6.1±0.416[c]	1.8±0.203[bcd]
Straw +sawdust	5.5±0.233[c]	1.4±0.088[abc]
Sand	1.6±0.176[b]	1.9±0.115[cd]
Saw dust	7.7±0.458[d]	2.6±0.088[d]
Straw	0.4±0.208[a]	0.7±0.353[a]
Control	9.6±0.404[e]	4±0.458[e]
LSD (0.05)	1.106	0.799
F- probability	***	***
CV	11.07	23.7
	5.2	1.9

*Description: The same letter represents statistically at par while the symbols *, ** and *** represent significant difference at p value at 0.05, 0.01 and 0.001, respectively*

Shrinkage (%)

Shrinkage percentage varied markedly ($p < 0.05$) among different treatments across different storage durations. The use of straw as a storage material revealed the lowest shrinkage on days 28 (0%), 56 (0.77%), and 84 (6.6%) days after storage, followed by sand on day 28 (0.03%), straw+sand+sawdust on days 56 (1.13%) and 84 (6.6%), all of which were statistically at par ($p > 0.05$) with straw. In contrast, the turmeric rhizome shrank more in storage without using any storage material. This might be due to the insulating behaviour of straw, which retains moisture within rhizomes, thereby reducing shrinkage (Nandini et al., 2014).

Table 3: Effect of different storing materials on the shrinkage (%) of turmeric

Treatment	Shrinkage (%)		
	28DAS	56DAS	84DAS
Straw +sand +saw dust	0.05±0.01[b]	1.13±0.088[ab]	6.6±0.058[a]
Sand +sawdust	0.11±0.012[c]	4.6±0.173[d]	11.8±0.176[d]
Straw +sawdust	0[a]	1.43±0.145[bc]	8.3±0.176[b]
Sand	0.03±0.015[ab]	2±0.153[c]	9.4±0.24[c]
Saw dust	0.18±0.015[d]	5.73±0.233[e]	12.9±0.318[e]
Straw	0[a]	0.77±0.088[a]	6.6±0.145[a]
Control	0.25±0.012[e]	7.1±0.265[f]	17.7±0.348[f]
LSD (0.05)	0.033	0.580	0.668
F- probability	***	***	***
CV	20.8	10.02	3.59
	0.09	3.25	10.5

*Description: The same letter represents statistically at par while the symbols *, ** and *** represent significant difference at p value at 0.05, 0.01 and 0.001, respectively*

CONCLUSION

The present study clearly revealed that the selection of storage material significantly influenced the postharvest quality and shelf-life of turmeric rhizomes. Among the different storage materials evaluated, all storage materials performed better than control (storage without storage material); straw being most consistently superior in all parameters, i.e., weight loss (%), shrinkage (%), sprout elongation, insect incidence (%), and rotting (%) throughout the 84-day storage period. The effectiveness of the straw is mainly due to its insulating properties, which buffer against temperature fluctuations and also maintain moisture levels. It creates an environment which is not suitable for the proliferation and growth of disease-causing organisms. Even though, use of straw with other materials, such as sand or sawdust, also provides better results as compared to the control, straw alone provided the most consistent better results. In contrast, storage of turmeric rhizomes without any material exhibited the worst results in all parameters, highlighting the importance of adequate storage materials. These results valued a straw as a scientifically and practically better option for storage, offering a cost-effective, environmentally friendly and locally available approach.

REFERENCES

Aggarwal, B. B., Yuan, W., Li, S., & Gupta, S. C. (2013). Curcumin-free turmeric exhibits anti-inflammatory and anticancer activities: Identification of novel components of turmeric. *Molecular Nutrition and Food Research, 57(9),* 1529–1542. doi.org/10.1002/mnfr.201200838

Bhattarai, D. R. (2018). Postharvest horticulture in Nepal. *Horticulture International Journal*, 2(6), 458–460. doi.org/10.15406/hij.2018.02.00096

Bisen, D., Bisen, U., & Bisen, S. (2019). Studies on major insect pests of rice crop (*Oryza sativa*) at Balaghat district of Madhya Pradesh. 625. *Journal of Entomology and Zoology Studies, 7(2),* 625–629.

Bunsa, D. S. (2019). Evaluation of post-harvest practices on Turmeric (*Curcuma longa* Linn) in relation to quality among selected four barangays of Marantaolanao Del Sur. International Journal of Science and Management Studies (IJSMS), 81–86. doi.org/10.51386/25815946/ijsms-v2i1p110

Chandran, B., & Goel, A. (2012). A randomized, pilot study to assess the efficacy and safety of curcumin in patients with active rheumatoid arthritis. *Phytotherapy Research, 26(11)*, 1719–1725. doi.org/10.1002/ptr.4639

Chattopadhyay, I., Biswas, K., Bandyopadhyay, U., & Banerjee, R. K. (2004). Turmeric and curcumin: Biological actions and medicinal applications. *Current Science, 87*(1), 44–53.

Dodamani, S., Sharatbabu, A. & Pujari, R. (2017). Effect of seed rhizome treatment on turmeric cv. Salem for growth, yield and quality attributes. *Int. J. Pure App. Biosci. 5(2),* 1063-1067.

Domestua, C. (2019). Processing of turmeric. Advances in Post Harvest Managment, Processing and Value Addition of Horticultural Crops Part -2, December.

Food and Agriculture Organization. (2010). Postharvest management of food crops. FAO. Retrieved from https://www.fao.org/4/x5672e/x5672e08.htm

Ghimire, K., Kafle, B., & Acharya, B. (2020). Status and constraints of turmeric production in Nepal: A case study of Kailali district. *Journal of Agriculture and Environment*, *21*, 103–112. doi.org/10.3126/aej.v21i0.33457

Jayaweera, W. M. C. S., Amarasinghe, S. R., & Ranawake, A. L. (2024). Effect of paddy straw, paddy husk, and cinnamon residue as mulching in Turmeric (*Curcuma longa* L.)

cultivation in low country wet zone in Ultisols. AGRIEAST: *Journal of Agricultural Sciences, 18(2),* 30–42. doi.org/10.4038/agrieast.v18i2.135

Jayawickrama, J. A. S. N. P., Salgdoe, A.S.A, & Fernando, T. (2016). Performance evaluation of fresh ginger (*Zingiber officinale*) for Storage under Selected Methods. Proceedings of 15th Agricultural Research Symposium (2016), 289–292.

Jibat, M. & Alo, S. (2023). Postharvest spoilage pathogen associated with turmeric (*Curcuma longa* L.) product in Southwestern Ethiopia. *Int. J. Agril. Res. Innov. Tech. 13(1),* 1-5. doi.org/10.3329/ijarit.v13i1.67943

Kafiya, M., Sutrisno, N., & Syarief, R. (2016). Perubahan kadar air dan pati ubi jalar (Ipomea batatas L.) segar pada sistem penyimpanan sederhana. Jurnal Penelitian Pascapanen Pertanian, 13(3), 136–145. https://doi.org/10.21082/JPASCA.V13N3.2016.136-145

Kahramanoğlu, İ. (Ed.). (2017). Postharvest handling. BoD – Books on Demand. https://doi.org/10.5772/66538

Khanal, A., Devkota, H. P., Kaundinnyayana, S., Gyawali, P., Ananda, R., & Adhikari, R. (2021). Culinary herbs and spices in Nepal: A review of their traditional uses, chemical constituents, and pharmacological activities. *Ethnobotany Research and Applications 21(1),* 1–18. doi.org/10.32859/ERA.21.40.1-18

Kumar, S. C., Bhai, S. R., Editors Lijo Thomas, T. C., & Publisher Director, R. P. (2015). Turmeric: Extension Pamphlet (pp. 1–13). ICAR- Indian Institute of Spices Research.

Li, S., Yuan, W., Deng, G., Wang, P., Yang, P., & Aggarwal, B. B. (2011). Chemical composition and product quality control of turmeric (*Curcuma longa* L.). *Pharmaceutical Crops, 2*, 28–54. doi.org/10.2174/2210290601102010028

MoALD. (2024). Statistical information on Nepalese Agriculture. MoALD, Singhadurbar, Nepal.

Mukrimaa, S. S., Nurdyansyah, Fahyuni, E. F., Yulia Citra, A., Schulz, N. D., Taniredja, T., Faridli, E. M., & Harmianto, S. (2016). Covariance structure analysis of health related indicators among home-dwellling older aduls focusing on subjective health perception. Jurnal Penelitian Pendidikan Guru Sekolah Dasar, 6 (August), 128.

Nandini, K., Singh, M. S., Lhungdim, J., Nanita, H., Diana, S., & Dorendro, A. (2014). Effect of rice husk on storage of seed rhizome of turmeric (*Curcuma longa* L.) . *Agricultural Science Digest - A Research Journal, 34(3),* 199. doi.org/10.5958/0976-0547.2014.01001.5

Pongener, A., Sagar, V., Pal, R. K., Asrey, R., Sharma, R. R., & Singh, S. K. (2014). Changements physiologiques et qualitaprs-rcolte durant la maturation du fruit de la grenadille (Passiflora edulis Sims). *Fruits, 69(1),* 19–30. doi.org/10.1051/fruits/2013097

Sarathi, V., Senthil, R., Panneerselvam, A., & Sri, A. V. V. M. (2014). Studies on rhizome rot pathogen in *Curcuma longa*. *International Journal of Current Microbiology and Applied Sciences, 3(8).*

Yashothai, R. (2019). Storage losses in feed ingredients by insects and its control. International *Journal of Science, Environment and Technology, 8(1),* 44-49.

Yewle, N., Swain, K. C., & Mann, S. (2023). A potential approach to selecting an appropriate hermetic storage system for high-value crops. *Applied Engineering in Agriculture, 39(6),* 1121–1132.

Yong, X. (2019). Straw raw material is storage device in advance.

Zuniega, J. S., & Esguerra, E. B. (2019). Extending the storage life of fresh turmeric (*Curcuma longa* L.) rhizomes through light and temperature manipulation. *Philippine Journal of Crop Science, 44(1),* 18–24.