

Research Article

Adoption of post-harvest handling practices by ginger farmers in Palpa district, Nepal

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ARTICLE INFO

Received: September 28, 2023
Revised: October 14, 2023
Accepted: October 14, 2023
Published: October 15, 2023

Keywords:

Ginger; grading; packaging;
post-harvest; value addition;
turmeric

ABSTRACT

Ginger has the potential for export and increased income for farmers in Nepal. Proper post-harvest handling practices has led to low market prices and significant post-harvest losses of ginger. This study was conducted in Palpa district to examine the post-harvest practices and technology adoption among ginger farmers. Data from 66 farmers in Bagnashkali, Purbakhola, Nisdi, and Rampur municipalities was collected through interviews, key informant interviews, and focus group discussions. Descriptive analysis was performed using MS Excel and SPSS. Results showed that 72.7% of farmers practiced storage, with Bhakari (60.41%) and Pit (39.59%) being the common storage types. Storage molds affected 72.2% of respondents, while 28.8% reported wrinkling during storage. Washing was practiced by only 7.6% of farmers. Manual grading was reported by all respondents, with no commercial grading observed. Black sutho production was carried out by 65.2% of farmers. Value addition activities such as sorting were practiced by 65% of respondents, while 25% engaged in transportation and packaging. Respondents' awareness of ginger post-harvest practices varied, with 75.76% having low awareness, 16.66% medium awareness, and 7.58% high awareness. Farmers' general precautions during harvesting, such as avoiding rhizome injury and minimal trimming and sorting, were not accompanied by specific precautionary practices, contributing to their challenges. The findings emphasize the importance of adopting modern post-harvest practices to increase production, improve product quality, and command higher market prices. Implementing these measures will enable ginger farmers in Palpa district to enhance their income and contribute to the growth of the ginger industry in Nepal.

INTRODUCTION

Agriculture is a critical component of the global economy, with billions of people relying on it for their livelihoods and sustenance [1–3]. Ginger (*Zingiber officinale*, Rosc), a member of the Zingiberaceae family, is a versatile perennial herbaceous monocotyledon widely cultivated as an annual crop [4]. Its rhizome, known for its distinctive aroma and flavor, plays a pivotal role in global cuisine, acting as a spice, flavoring agent, and traditional herbal remedy with anti-emetic, antioxidant, and anti-inflammatory properties [5]. The multifaceted utility of ginger extends its influence across culinary traditions and medicinal practices worldwide [6]. It serves not only as a stimulant but also as a carminative, addressing ailments such as nausea, diarrhea, and stomachaches [7]. Ginger's rhizome can be harnessed to produce a myriad of commodities, ranging from fresh and dried forms to the steam distillation of its essence, yielding ginger paste, preserved ginger, dry ginger, ginger powder, ginger oil, and ginger oleoresin [8]. Innovations have led to the development of ginger leathers, bars, juice, scent, appetizing flakes, crude fiber, and ginger starch, further diversifying its applications [9]. In the context of Nepal, ginger stands as a high-value spice crop with immense export potential [10]. Nepal has ascended to become the fourth-largest ginger producer globally, boasting an impressive total ginger cultivation area of 21,912 hectares and a production output of 279,206 metric tons [11]. Notably, ginger production thrives in districts such as Illam, Salyan, Palpa, Tanahun, Sindhuli, Doti, and Kaski, where the ginger industry plays a pivotal role in contributing to Nepal's agricultural landscape. Nepal's ginger output contributes significantly, accounting for 9.21% of the global production [10], with India serving as its major export destination [12], absorbing about 99% of Nepal's ginger, predominantly in the form of fresh ginger, alongside a notable volume of dried ginger, locally referred to as "sutho" [13]. About 1,150 hectares of land in Palpa is under ginger cultivation, with a production of 14,734 metric tons and a productivity of 12.81 metric tons per hectare [11]. The Prime

Minister Agriculture Modernization Project (PMAMP) designated this area as a "Ginger/Turmeric" zone in the years 2021–2022. The district has 6,140 farmers and 148 farmer groups [14].

However, despite the promising prospects of ginger cultivation in Nepal, certain critical challenges threaten the sustainability and profitability of this industry. One of the pressing issues is the inadequate adoption of post-harvest handling practices by ginger farmers [14]. In the picturesque Palpa district, an essential ginger-producing region, the lack of awareness and implementation of sound post-harvest management methods is glaring. Ginger rhizomes, post-harvest, are often tainted with soil due to suboptimal storage facilities. Consequently, ginger production in the Palpa district has witnessed a significant decline, plummeting by 95%, primarily attributed to market uncertainty. In addition, prevalent misconceptions among farmers, such as the belief that washing reduces the shelf life of ginger and diminishes its weight, lead to lower market prices [13].

Post-harvest losses, encompassing the reduction in crop quantity and quality after separation from the production site, serve as a pertinent concern in the ginger industry, particularly for export markets [15]. The absence of robust post-harvest management practices, including cleaning, grading, packing, shipping, and storage, has exacerbated these losses, limiting the marketability of Nepalese ginger [16]. Moreover, diversifying ginger products such as dry ginger, ginger oil, ginger pickle, and ginger squash remains an untapped opportunity. In recent years, the global production of ginger has decreased due to several factors, including diseases and fluctuations in global prices.

In light of these challenges and opportunities, this research seeks to investigate the adoption status of post-harvest handling practices and technology among ginger farmers in the Palpa district of Nepal. By shedding light on the prevailing practices, barriers, and potential



solutions, this study aims to contribute valuable insights that can enhance the ginger industry's sustainability and profitability. This study objectives encompass examining the adoption levels of post-harvest practices, identifying challenges hindering adoption, and exploring the factors that influence farmers' decisions regarding post-harvest handling. Ultimately, this research endeavors to bridge the existing research gap by providing empirical evidence and practical implications for the ginger farming community, policymakers, and stakeholders in Nepal's ginger industry. In doing so, it aspires to pave the way for improved post-harvest practices, reduced losses, and enhanced value addition, ultimately benefiting ginger farmers and the industry as a whole.

MATERIALS AND METHODS

Study area, sample size, and data collection technique

The research was conducted in selected areas within the Palpa district, situated in the mid-hill region of Lumbini province, Nepal (Figure 1). Specifically, the study encompassed the Bagnaskali, Purbakhola, Nisdi rural municipalities, and Rampur municipality. The investigation took place from February to July 2022 at a study site with precise geographical coordinates: latitude 27°49'36.48" N and longitude 83°38'16.44" E, and an elevation ranging from 152 to 1936 meters above mean sea level. The research regions were deliberately selected due to their significance as locations for ginger cultivation.

The entire ginger-producing population of Palpa district constituted the sampling frame for this study. To ensure unbiased representation, a simple random sampling technique was employed. A multifaceted approach to data collection was adopted, employing various procedures and methods. These included interviews, key informant interviews (KII), and focal group discussions (FGD), following the protocols outlined by Ghimire and Gyawali [17], Ghimire and Chhetri [18], and Ghimire and Kandel [19]. Additionally, a comprehensive review of pertinent literature was undertaken to gather secondary information. A total of 66 ginger farmers, drawn from three distinct rural communities, were selected as samples for this study.

Statistical analysis

The gathered data and information were input, coded, and analyzed using different statistical programs, including MS Excel 2010 (Version: 4.0.4734.1000, Washington, US) and SPSS (Version: IBM SPSS Statistics 28, New York, USA). The data for the variables gender, age, religion, family size, educational attainment, principal occupation, and adoption of post-harvest management procedures were all subjected to descriptive analysis using mean and percentage statistics.

Problems in the adoption of post-harvest practices and technology

Using MS Excel 2010 (Version: 4.0.4734.1000, Washington, US), the indexing/scaling technique was used to create an index for prioritizing the issues based on farmers' perceptions. The index for the intensity of problems faced by respondents in the adoption of post-harvest practices and technology was computed by using the formula [20].

$$I_{\text{prob}} = \sum SiFi / N$$

(1)

Where, I_{prob} = index value for intensity, Σ = summation, S_i = scale value of i th intensity, F_i = frequency of i th response, N = total number of respondents.

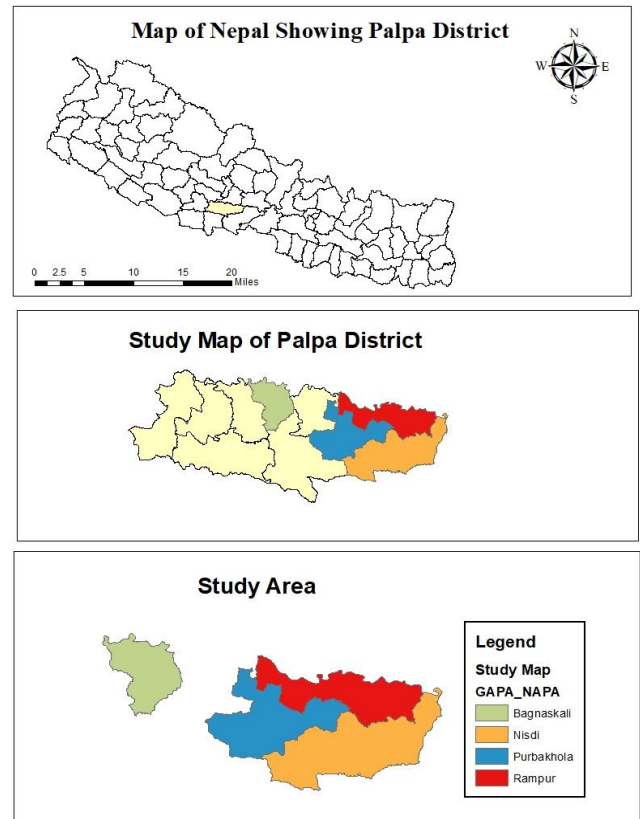


Fig. 1. Map of Nepal showing the study site.

RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

Socio-economic factors such as age, level of education, years of experience, and farm size are utilized as variables to elucidate the choices made by farmers when adopting technology or implementing specific practices [21]. The study showed that the majority of respondents were female. Among the 66 ginger-growing farmers surveyed, 42 were female farmers, while the remaining 24 were male farmers. This distribution represents 63.3% female farmers and 36.4% male farmers, highlighting a prevailing trend where females have taken on a significant role in post-harvest activities. This might be due to male migration, leaving women primarily responsible for agricultural tasks [22]. Age is a significant demographic factor that influences the efficient allocation of resources since it reveals a person's aptitude for work, productivity, desire for advancement, and attitude toward many social and economic facets of life. According to the field survey data, in the research region, 59.1% of respondents were between the ages of 16 and 59, and 40.9% were over 60. According to the aforementioned statistics, agriculture employs a larger portion of the younger population.

People of the Janajati, Brahmin/Chhetri, and other ethnic groups predominate in the research region. According to the study, the Janajati (51.5%) community was the dominant ethnic group in the study region, followed by others (39.4%), Brahmin/Chhetri (7.6%),

and Dalit (1.5%). The Hindu faith completely dominated local society. Hinduism was practiced in every one of the tested families. None of the research area's ginger farms included households that practiced Buddhism, Christianity, or Islam.

As stated in Table 1, all households were divided into three categories. According to the results of the field survey, the majority of homes (86.4%) have families with three to eight people, while just 4.5% of households have families with fewer than three members. One of the key elements in the socioeconomic growth of a community or a country is education [23,24]. Three categories were created in this study to classify the education levels. Those who are illiterate are incapable of reading or writing. The primary level was defined as having completed formal education up to class five, and the secondary level as finishing with the School Leaving Certificate (SLC) or above. According to the survey, 45.5% of the respondents had finished their elementary schooling, while 24.2% had finished their secondary schooling. The study also indicated that 30.3% of the respondents were illiterate. Individuals with a higher level of education are expected to exhibit a more favorable attitude toward accepting and utilizing technology [25]. A large primary source of income for households was determined by the survey to be agriculture (60%) with non-farm sources (23%) coming in second. Remittance (15%) and government service (2% each) made less of an impact on the main occupation. Table 1 provides further information on families' major occupations. According to the survey, the average amount of land owned by a household ranged from 0.05 to 1.53 hectares and was determined to be 0.58 hectares (Table 1). The average landholding of a household was higher than the district's average landholding (0.50 hectares). Additionally, it was determined that the household's average area under ginger cultivation, which ranged from 0.05 to 0.61 hectares, was 0.15 hectares. Landholdings and education level are widely acknowledged as crucial factors that significantly influence the decision-making process and adoption of technology in agriculture [21].

The adoption of post-harvest management procedures depends heavily on training. Results indicated that only 28.8% of respondents had access to PMAMP training. The remaining 71.2% of respondents didn't receive any ginger training. As a result, these farmers did not implement post-harvest management procedures. The adoption of excellent agricultural techniques is significantly influenced by agricultural subsidies. According to the survey, the majority of respondents (83.3%) did not get any type of subsidy program, and just 16.7% did. As a result, these farmers did not implement adequate post-harvest management methods. The findings suggest that a limited number of households' heads have received subsidies, primarily due to the scarcity of extension agents and a lack of knowledge. Additionally, the majority of farmers are unable to access subsidies due to the remote locations where they reside.

Harvesting of ginger

Based on the responses received, it was found that all farmers engage in the manual harvesting of ginger using traditional methods. The harvesting of ginger takes place nine months after plantation, typically in November, when the ginger rhizome reaches full maturity. Farmers carry out two harvests per year, one in June and one in July, primarily for selling seed rhizomes in the market when ginger prices are higher compared to the main harvesting season in November.

Table 1. Summary statistics of socio-demographic variables of respondents.

Variable	Frequency	Respondent percentage (%)	
Gender			
Female	42	63.3	
Female	24	36.4	
Age			
Between 16-59 years	39	59.1	
Above 60 years	27	40.9	
Ethnicity			
Janajati	34	51.5	
Brahmin/Chhetri	5	7.6	
Dalit	1	1.5	
Others	26	39.4	
Religion			
Hinduism	66	100	
Family size			
Greater than 8 members	6	9.1	
Between 3-8 members	57	86.4	
Less than 3 members	3	4.5	
Education level			
Illiterate	20	30.3	
Primary	30	45.5	
Secondary	16	24.2	
Primary occupation			
Agriculture	39	59.1	
Government-service	1	1.5	
Off-farm	16	24.2	
Remittance	10	15.2	
Training obtained by the respondents			
Training received	19	28.8	
Training not received	47	71.2	
Subsidy obtained by the respondents			
Not received	55	83.3	
Received	11	16.7	
Landholding			
	Minimum (ropani)	Maximum (ropani)	Mean (ropani)
Landholding	1	30	11.44
Ginger cultivation area	1	12	2.88

Precaution to protect ginger quality

Farmers take certain precautions to safeguard the quality of ginger during the harvesting process. They make conscious efforts to avoid injuring the rhizomes while harvesting. Additionally, they undertake activities such as trimming, curing, and sorting before supplying the ginger to traders, but very rarely. However, apart from these measures, there are no other specific precautionary practices implemented by farmers to protect the quality of ginger. It is worth noting that farmers preserve the larger-sized rhizomes as seeds for obtaining good-quality ginger the following year.

Adoption of post-harvest handling practices

Means of transportation and transportation materials

From the study, it was concluded that the majority of households (89.4%) manually transport ginger from the field to the home or collection center after harvesting (Table 2). Only a few households (10.6%) used tractors as means of transportation. The main forms of conveyance are doko (a traditional tool made of bamboo is commonly

used for carrying goods) and gunny bags. According to the survey, 10.61% of the homes used gunny bags for transportation, while 89.39% of the households utilized doko (without packaging).

Table 2. Transportation and packaging materials used by ginger farmers in Palpa district, Nepal.

Description	Frequency	Respondent percentage (%)
Means of transportation		
Manually	59	89.4
Tractors	7	10.6
Transportation materials used		
Doko (without packaging)	59	89.39
Gunny bags (packaging)	7	10.61

Storage

Storage facilities are essential for extending raw ginger's shelf life after harvest and contributing to its value. The investigation showed there was no ginger storage facility with a temperature, relative humidity, and ventilation management system. In the research region, ginger is often preserved for domestic use, before being marketed, as well as for seed purposes. According to the survey, the majority of homes (72.7%) have accepted the habit of storing ginger, while 27.3% of them have not.

Types of ginger storage and problem during storage

In the study area, it was found that ginger was stored in traditional ways, i.e., in pits and bhakari (Table 3). From the study, it was found that 60.41% of households store ginger in Bhakari, which was followed by pit storage (39.59%). Due to the study's use of conventional techniques for ginger preservation, several issues, including storage molds and wrinkling, were common. Storage molds made up the bulk of issues (72.2%), while wrinkling came in second (28.8%).

Washing, grading and packaging practice

The washing practice gives ginger an appealing look and is easily accepted in the local market. In the study, it was found that the majority of households (92.4%) did not adopt washing practices. While 7.6% of households adopted the washing practice, they also reported that washed ginger gets a higher price and higher preference from retailers and consumers in comparison to unwashed ginger. In the study, it was found that grading practices were done manually in traditional ways. It was found that no commercial grading practice was adopted in the study area. There is no advanced packaging practice adopted in the study area. Most gunny bags are used as packaging materials (10.61%).

Ginger products and value addition

From the study, it was concluded that the majority of households (65.2%) had made black sutho, while 34.8% of households had not made black sutho. It was found that none of the households adopted post-harvest handling practices to make ginger products like dry ginger, ginger powder, ginger candy, ginger pickle, ginger squash, and ginger oil extraction. Approximately 65% of the farmers engage in sorting as a means of adding value to their products. Additionally, some farmers practice grading to enhance the value of their produce, while 25% of farmers focus on activities such as transportation and packaging to increase the value of their goods.

Awareness about post-harvest handling practices

The distribution of respondents in Table 3, based on their level of awareness of post-harvest management practices, reveals that a significant majority (75.75%) falls under the 'low' category, followed by 16.66% in the 'medium' category, and 7.57% in the 'high' category of adoption of post-harvest management practices. This suggests that a considerable number of vegetable growers may not have been adequately exposed to post-harvest management practices.

Table 3. Different post-harvest adoption practices adopted by ginger farmers in Palpa district, Nepal.

Description	Frequency	Respondent percentage (%)
Storage		
Practiced	48	72.7
Not practiced	18	27.3
Types of ginger storage		
Bhakari	40	60.41
Pit	26	39.59
Problems during storage		
Storage molds	48	72.2
Wrinkling	18	28.8
Washing practice		
Practiced	5	7.6
Not practiced	61	92.4
Grading practice		
Manually	66	100
Commercial grading	0	0
Ginger products		
Black sutho	43	65.2
Not black sutho	23	34.8
Value addition		
Sorting	43	65
Transportation and packaging	23	25
Respondents awareness on ginger post-harvest practices		
Low	50	75.76
Medium	11	16.66
High	4	7.58

Major problems in the adoption of post-harvest handling practices

Responses regarding various constraints in the adoption of post-harvest handling practices were recorded and analyzed during the field study. The respondents were asked to rank the constraints they had been facing in the adoption of post-harvest practices and technology. Table 4 reveals that lack of knowledge ranks in the first position with an index value of 0.763. Similarly, lack of extension services ranks in 2nd place with an index value of 0.754, followed by lack of modern technology and equipment, disease and pests, and lack of labor.

Table 4. Major problems in the adoption of post-harvest practices and Technology.

Problems in the adoption of post-harvest practices and technology	Index value	Rank
Lack of knowledge	0.763	1st
Lack of extension services	0.754	2nd
Lack of modern technology and equipment	0.536	3rd
Disease and pest problem	0.451	4th
Lack of labor	0.442	5th

Factor affecting adoption of post-harvest handling practices

The adoption level of post-harvest practices is relatively low, with an acceptance rate of 70%, as shown in Table 5. This suggests that respondents have not fully embraced post-harvest adoption practices. It can be inferred that farmers with limited knowledge and awareness regarding technology and practices are more inclined to refrain from adopting post-harvest practices [26]. According to the findings of this study, performance expectancy demonstrates a high frequency (42), indicating that it can be considered the most influential factor in determining a user's behavioral intention to adopt post-harvest practices. The effort expectation stands out with the highest frequency (47). It is known that effort expectancy plays a significant role in influencing users' intentions to adopt and accept new technologies [27]. Additionally, having knowledge and understanding of new technologies or practices is an important contributing factor that influences the willingness to adopt such practices. This study, supported by a majority of respondents (60.62%), has confirmed that social influence plays a significant role in the adoption of post-harvest practices. Farmers in the study have acknowledged that various entities, such as the government, extension agents, friends, and family, have actively encouraged them to adopt post-harvest practices. In this study, factors such as financial support, necessary knowledge, resources, training, and facilities were identified as components of facilitating conditions that have the potential to influence the adoption of new technologies or practices. The findings indicate that ginger farmers in Palpa district agree that facilitating conditions have played a significant role in motivating them to adopt post-harvest practices. Attitude can play a significant role in contributing to post-harvest losses of fruits and vegetables [28]. In line with this, the current study's findings also indicate a high frequency (42) of positive attitudes among farmers towards ginger post-harvest management practices.

Table 5. Factors influencing ginger post-harvest handling practices.

Factors	Frequency	Respondent percentage (%)
Post-harvest practices adoption		
Low	46	70
Medium	20	30
High	0	0
Performance expectancy		
Low	10	15.15
Medium	14	21.21
High	42	63.64
Effort expectancy		
Low	5	7.58
Medium	14	21.21
High	47	71.21
Social influence		
Low	5	7.58
Medium	21	31.82
High	40	60.60
Facilitating conditions		
Low	11	16.67
Medium	20	30.30
High	35	53.03
Attitude		
Low	4	6.06
Medium	20	30.30
High	42	63.64

SWOT analysis of ginger sub sector

Strength, weakness, opportunities and threats (SWOT) analysis of ginger in Palpa district, Nepal is presented in Table 6.

Table 6. SWOT analysis of ginger in Palpa district, Nepal

Strength	Weakness
Low labor costs.	Lack of appropriate ginger varieties.
Local traders make selling easy.	Insufficient physical facilities for washing and cold storage.
Smooth supply chain.	Inadequate irrigation facilities for timely watering.
Ginger with high oil content.	Limited technical knowledge among chain actors regarding production and quality management.
Strong market demand.	Infrequent availability of services from service providers.
More profitable than other crops.	Lack of organization among growers, resulting in individual actions.
Ideal soil and climate for ginger.	Shortage of skilled labor for ginger harvesting.
Consumers love Palpa district ginger.	Non-functioning collection centers.
Opportunities	Threats
Geographic and climatic suitability for ginger cultivation.	Variable weather conditions, including the possibility of high rainfall and drought during production.
Strong market demand in the international market.	Incidence of diseases and pests affecting ginger crops.
Potential for expanding the production area.	Illegal charges for custom clearance and SPS (Sanitary and Phytosanitary) certification at the Indian border.
Possibility of product diversification, such as jam and jelly, for added value.	Competition in the international market.
Increased employment opportunities.	Lack of clear government policy for the development of physical infrastructure.
Government policies supporting the development of value chains for high-value crops.	Unstable market prices for ginger.
Export potential for ginger. Top of Form	Farmers generally have limited control over determining the price of their ginger produce. Top of Form

CONCLUSION

From this study, the majority of ginger farmers were not familiar with post-harvest methods and technology. The research found that the majority of families moved ginger manually from the field to their residences or gathering locations. Similarly, no storage facility in the study area had a system for controlling temperature and humidity. Given that diverse goods such as dried ginger, ginger powder, candies, and oils were not processed in the research location, extension services highlighting the value of these diversified products had to be made available on the global market. The study found that the main obstacle to the adoption of post-harvest handling procedures was lack of knowledge; as a result, knowledge about these practices should be spread via radio, television, newspapers, and social media. There is an immense need for strategic plans to be formulated by the concerned authority to address the major constraints in the adoption of post-harvest practices and technology faced by farmers and come up with measures to solve the prevailing constraints. However, it is important to acknowledge certain limitations that should be addressed to enhance the understanding of future research. Firstly, conducting future studies on ginger could involve exploring different states or even countries to obtain a broader perspective. Additionally, it is

crucial for future research to encompass various stages and types of post-harvest practices adopted by ginger farmers. This would enable a more comprehensive analysis of the adoption levels and provide a deeper understanding of the subject matter.

ACKNOWLEDGMENT

The authors are thankful to the Prime Minister Agriculture Modernization Project, Agriculture and Forestry University for facilitating the study.

AUTHOR CONTRIBUTIONS

BPC and SKC conceived the study, curated the data, and contributed to methodology; SKC and BPC obtained funding; SKC, BPC, and SG conducted the investigation; SG provided resources and software; SG and SKC supervised the project; SG validated the findings; BPC visualized the data; SG and BPC drafted the original manuscript and conducted the review and editing process.

FUNDING

The authors did not receive any direct funding from an individual or institution to conduct this research.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

INSTITUTIONAL/ETHICAL APPROVAL

The authors do not involve any approval as the work does not contain human or animal participants or experiments.

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