International Journal of Life Science and Agriculture Research

ISSN (Print): 2833-2091, ISSN (Online): 2833-2105

Volume 03 Issue 12 December 2024

DOI: https://doi.org/10.55677/ijlsar/V03I12Y2024-21

Impact Factor: 6.774 , Page No : 1063-1073

Economics of Drying and Storage Methods of Large Cardamom (*Amomum subulatum* Roxb.) Among Smallholder Farmers in Gandaki Province, Nepal

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ABSTRACT: Smallholder farmers lack knowledge of postharvest management of freshly harvested large cardamom capsules thus they make uneconomical decisions on the drying and storage of capsules and are unaware of the amount of income lost resulting from it. This paper aimed to assess the drying and storage benefits and efficiency of drying and storage methods used by smallholder farmers. An interview-based questionnaire survey of 320 randomly selected large cardamom cultivating farmers was conducted in Gandaki province, Nepal to collect the data. The collected data were processed and analyzed by using Microsoft Excel and Statistical Package of Social Sciences Version 26. The study revealed that a double drum dryer was the most popular drying method of drying capsules adopted by 59.1% of farmers followed by a traditional kiln and electric dryer. Among four types of storage methods used for storing dried capsules, two-fifths of farmers used jute sacks. The highest average drying cost per kg of capsule was found in traditional kilns (NRs 476.87). The highest drying benefit and drying efficiency were found in electric dryer NRs 676.34 per kg and 68.95% respectively. The difference in the mean of drying benefit and drying efficiency of the three drying methods were statistically significant at a 0.1% level of significance. Storage cost was lower in wooden boxes and average storage benefit was lower in black polythene-lined gunny bags in the sixth month of storage of dried capsules. The average storage efficiency of wooden boxes was found to be the highest among the four storage methods i.e. 52.89%. These findings suggested that the electric dryer should be promoted for drying capsules and a wooden box for storing dried capsules.

Published Online: December 26, 2024

KEYWORDS: Benefit, capsule, cost, dryer, efficiency, Nepalese rupees

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INTRODUCTION

Large cardamom (*Amomum subulatum* Roxb.) is one of the lucrative and promising, potential and viable high value low volume cash crops of the mid hills regions of Nepal and is the main sources for the monetary requirement to the rural farmers (Kattel et al., 2020). Hence, it has direct and leading impact on the economy of the rural people (Kandel, 2019), thereby contributing significantly in alleviating poverty of the people living in mid-hills areas (Kalauni & Joshi, 2020). Large cardamom, also known as the "Queen of spices" is purely exporting agro-commodity for earning foreign currency (Shrestha et al., 2018). Currently, Nepal being the highest producer of large cardamom, contributes 68% global market share, followed by India (22%) and Bhutan (9%) (ICIMOD, 2016). Large cardamom produced in Nepal has been considered as of superior quality in the international market (Shrestha et al., 2018).

Nepal is a world's top producer of large cardamom (Singh & Pothula, 2013). The total area, production and productivity of large cardamom in Nepal were 19145 ha, 8714 Mt and 0.55 Mt/ha respectively in fiscal year 2021/22 (MoALD, 2022). The cultivation of large cardamom is increasing day by day from east to west of the country. Gandaki province ranks second in terms of area and production with a total area, productive area, production and productivity of 1841 ha, 1054 ha, 541 Mt and 0.51 Mt/ha respectively in fiscal year 2021/22 (MoALD, 2022).

Large cardamom is a seasonal produce and requires proper drying and storage for quality maintenance. The moisture level of freshly harvested large cardamom capsules is in the range of 70 to 80% on the weight basis based on their maturity level (Oli, 2011). The moisture content is needed to be brought down below 10 to 12% earliest possible after harvest in order to ensure the longer shelf life of the capsule and to bring out and enhance the characteristic aroma of the capsule. Appropriate and efficient drying and storage methods enable farmers to store cardamom capsule and sell when prices are attractive for them (Tafera, 2012).

Lack of appropriate drying and storage facilities and with the existing indigenous traditional drying and storage methods for cardamom capsules result in spoilage, mould growth due to the lower reduction of moisture level in capsule after drying, shorter storability of dried capsules and potential physical damage of capsule due to fluctuating temperatures and infestation by pests and rodents (Dash et al., 2022). This reduces the shelf life of the capsule and lowers its value in the market. Inappropriate drying methods and storage methods have led to 12-15% capsule losses (Dash et al., 2022) due to which a significant amount of the capsule is lost every year resulting in economic losses of around NRs 24 Million per annum in Gandaki province, Nepal (MoLMAC, 2022). Smallholder farmers are unable to fetch the full profit potential from drying and storing cardamom as they lack effective methods for preserving their produce (Tafera, 2012). The adoption of improved drying structures promotes the shelf life of capsules, leading to principal savings mainly in the quality and quantity of stored products at the farm level (Dash et al., 2022).

After drying, cardamom should be winnowed to remove impurities and then stored in moisture-proof and air-tight methods away from direct sunlight to maintain quality year-round. Effective storage ensures a consistent supply, allowing producers to sell year-round with a price premium during the off-season.

Drying and storage of cardamom capsules involves significant costs and risks which can benefit farmers if managed well. Despite diverse drying and storage methods in Nepal, there is a lack of studies on farmers' status of these methods. This study aimed to evaluate the cost-effectiveness of quality drying and storage methods for cardamom capsules and to provide evidence-based recommendations to farmers, policymakers, and other stakeholders. The general objective of this research was to assess the economics of drying and storage methods of large cardamom among smallholder farmers in Gandaki province, Nepal and its specific objectives were to determine the drying and storage cost and to comparatively analyze the drying and storage benefit and efficiency of drying and storage methods of large cardamom adopted by farmers.

MATERIALS AND METHODS

Study site, sampling frame, sampling procedure and justification of sample selection

The study was carried out in Gandaki province, Nepal. The province is located in the nearly middle part of the country, Nepal and is bounded by 27° 20' and 29° 20' North latitudes and 82° 52' and 85° 12' East longitudes. The research was conducted in wards no. 4, 5 and 6 of Marshyangdi Rural Municipality, Lamjung District, wards no. 3, 5 and 6 of Madi Rural Municipality, Kaski District and wards no. 1 and 2 of Arughat Rural Municipality, Gorkha district. A multistage sampling technique was employed for the study. For the initial/first stage, Gandaki province was purposively selected for the research because the area and production of large cardamom have been growing proportionately more every year in the last three years in Gandaki province unlike other provinces (MoALD, 2022). Hence, Gandaki province is an emerging hub of large cardamom. In the second stage, Lamjung, Kaski and Gorkha district of Gandaki province was purposively selected since these three districts (1510 ha) covered 82.02% area of Large cardamom and 72.59% of the total production of large cardamom of Gandaki province (MoALD, 2022).

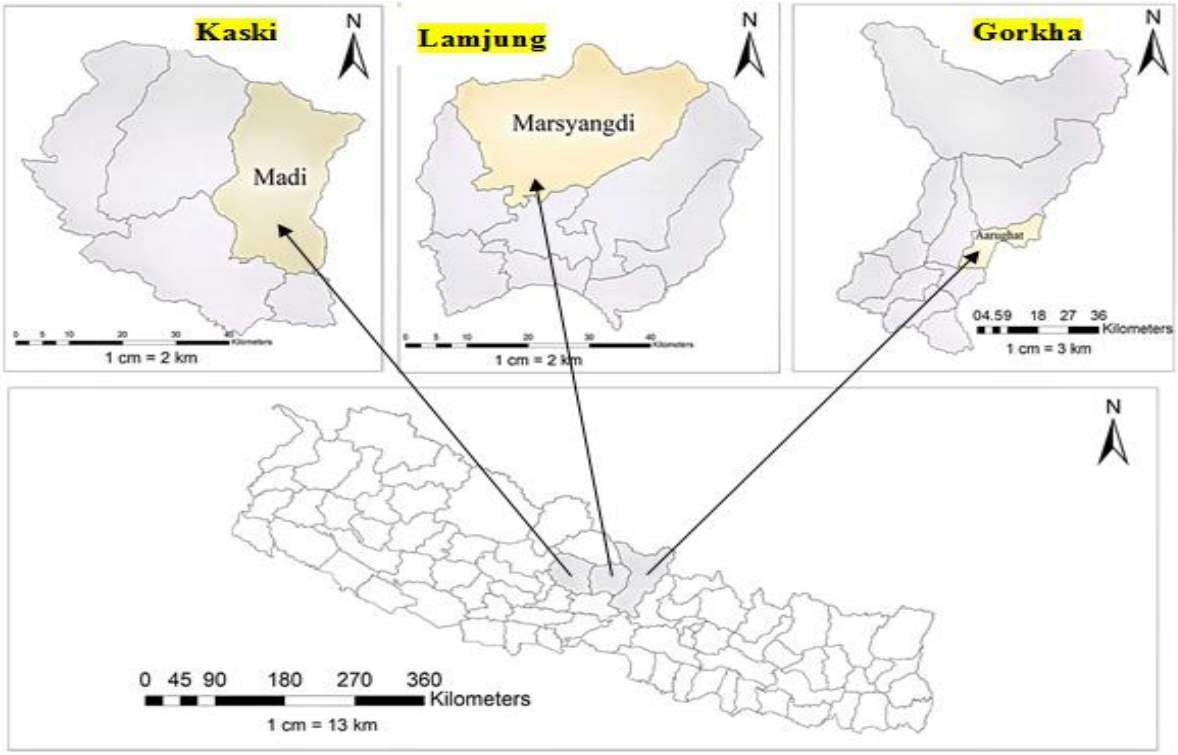

Figure 1: Map of Nepal showing study site

In the third and fourth stages, respective Rural Municipalities and respective wards from each Rural Municipality were purposively selected for data collection because each respective Rural Municipality of each selected district covered more than 70% cultivation area and more than 75% of the total production of respective districts and respective wards were the major large cardamom growing areas of each Rural Municipality. For sample selection, smallholders' large cardamom growing farmers i.e. farmers having less than 2 ha area for large cardamom farming (FAO, 2015) were taken for study. A sampling frame was generated, which comprised the households who are engaged in large cardamom farming within and around these local bodies of three districts. There are a total of 1600 small holders' large cardamoms farming households in these local bodies of three districts (MoLMAC, 2022).

The sample size for this study was calculated from the following formula 1 (Israel, 1992).

$n=N/(1+N*e^2)$ ……..……(1)

Where;

n = sample size, N= No. of ho households growing large cardamom in survey area e= acceptable sampling error (level of precision),

$n=1600/ (1+1600*.05^{2)} = 320$ (e was considered as 5%)

Based on the distribution of large cardamom farmers in each district, 130 samples were taken from Marshyangdi Rural Municipality, Lamjung, 100 samples were taken from Madi Rural Municipality, Kaski and 90 samples from Arughat Rural Municipality, Gorkha by simple random sampling procedure to avoid any sort of bias as this method provides an equal chance for a selection of the elements of the entire sampling frame as samples (Scheaffer, 1979).

Sources of data and data collection methods

The primary data was collected from household surveys, focus group discussions and key informant interviews. Based on the interview schedule and checklist, questions were asked to the large cardamom farmers to gain the aimed information. Focus group discussions were carried out with leader farmers and farmers' groups and key informant interviews were carried out with, traders, agriculture experts and researchers to validate the collected data through household surveys. The secondary data were collected through e-resources such as journal articles, newspapers, books and reports of different institutions.

Data analysis

Data collected from the field survey were organized, processed and tabulated in Microsoft Excel. Both descriptive and inferential analyses were done using MS Excel and Statistical Package for Social Sciences (SPSS)-version 26.

Data analytical framework and model specification

Drying benefit

Drying benefit refers to economic returns to drying. It represents the increase in value of large cardamom capsules than freshly harvested capsules resulting from the drying of freshly harvested cardamom capsules. The drying benefit was calculated by using the following formula:

$$DB= [P_d - (P_h+C_d)]$$

Where,

- DB= Drying benefit
- P_d = Price at the time of drying
- P_h= Price of freshly harvested capsule
- C_d= Drying cost

Various costs were included in the drying cost. They were handling and transport costs, labour costs, cost/rent of drying structure, depreciation cost, energy cost, cost of wastage (loss) maintenance cost, tax/interest cost and miscellaneous costs (cost of management and arrangement).

The drying benefit of various drying methods for large cardamom capsules was calculated and **t**heir means were compared with a one-way analysis of variance (ANOVA).

Storage benefit

Storage benefit refers to economic returns to storage. It represents the increase in value of large cardamom capsules than dried capsules resulting from storing dried capsules for a certain time. The economic return to storage (Storage benefit) was calculated by using the following formula:

$$SB= [P_s-(P_d+C_s)]$$

Where,

SB= Storage benefit

P_s = Price at the time storage period (s)

P_d= Price at the time of drying (d)

C_s= Storage cost from period d to s

d to s = Storage interval

Various costs were included in the storage cost. They were handling and transport costs, labour costs, cost of storage structure, rent of storage room, cost of wastage (loss), maintenance cost, tax/interest cost and miscellaneous costs (cost of management and arrangement).

Return to storage of various storage methods of large cardamom capsules was calculated for every month up to six months of storage and **t**heir means were compared with one-way ANOVA.

Drying efficiency of drying methods

The drying efficiency of a particular drying technique was calculated by using the following formula:

Drying efficiency of a drying technique (%) = (drying benefit of that technique/maximum possible drying benefit at the study site) *100

Maximum possible drying benefit was calculated in such a way that the wastage cost (drying loss was assumed to be 0%) was taken as NRs 0 and all other costs involved in drying freshly harvested capsules were taken as minimum values that were found in farmers' condition in the study area.

The average drying efficiency of various drying methods of large cardamom was compared with one-way ANOVA.

Storage efficiency of storage methods

Storage efficiency of a particular storage container for storing dried capsules for 6 months was calculated by using the following formula:

Storage efficiency of a storage container (%) for 6 months of storage = (storage benefit of that container for 6 months of storage/maximum possible storage benefit from 6 months of storage at the study site) * 100

Maximum possible storage benefit was calculated in such a way that the wastage cost (storage loss was assumed to be 0%) was taken as NRs 0 and all other costs involved in storing of dried capsule for 6 months were taken as minimum values that were found in farmers' condition in the study area.

The average storage efficiency of various storage methods of large cardamom capsules for storing capsules for six months was compared with one-way ANOVA.

RESULTS AND DISCUSSION

Socio-demographic characteristics

Landholding and land use pattern

Landholding indicates the total land owned by the households. The average landholding of the household was 0.87 hectares which was higher than Nepal's national average of 0.55 hectares (CBS, 2021). Similarly, the average area for cardamom farming was found to be 0.57 ha in the study area.

Table 1: Landholding and use pattern of respondents

Variables	Mean ± SD
Total Land holding (ha)	0.87 ± 0.36
Total Area for cardamom farming (ha)	0.57 ± 0.22
Percentage of cardamom farming area to total land area	65.12 ± 9.83
Productivity (Mt/ha)	0.54 ± 0.19

The area allocated for cardamom farming was found to be 65.12% of total land area. The average productivity of large cardamom in the study area was found to be 0.54 Mt/ha which is slightly lower than the national average of Nepal i.e. 0.55 Mt/ha but higher than that of Gandaki Province i.e. 0.52 Mt/ha (MoALD, 2022).

Out of the total sampled households, 10.63% of farmers responded that they had leased land for Cardamom farming having an average leased area of 0.47 ± 0.16 ha. Farmers in the study area produced an average of 3.23±1.37 quintal cardamom capsules ranging from 0.8 quintals to 8.1 quintals.

Disposable income distribution of the respondents from cardamom farming

Table 2 depicts that the estimated average annual family income of the respondents from cardamom farming was NRs 626875 ranging from the minimum NRs 220000 to the maximum NRs 1500000. Among the total respondents, 60.31 % had a yearly family income smaller than the average annual family income while the remaining 39.69% had an annual family income higher than the average.

Table 2: Disposable annual income distribution from cardamom farming in NRs of respondents

Disposable income distribution from cardamom farming in NRs	Frequency	Average	Minimum value	Maximum value
<300000	13 (4.06)			
300000-600000	165 (51.56)			
600001-900000	103 (32.19)	626875 ± 258962	220000	1500000
900001-1200000	25 (7.81)			
>1200000	14 (4.38)			
Total	320 (100.00)			

Figures in parentheses represent the percentage of respondents

Drying methods adopted

Double drum dryer was the most commonly used drying method with 189 (59. 1%) respondents used for drying fresh cardamom capsules in the study area as shown in figure 2. Likewise, the electric dryer was the least used drying method with only 33 (10.3%) farmers drying capsules with it while the traditional kiln was used by 98 (30.6%) respondents in the study area. On average, farmers dried capsules 1.88±0.76 times per year ranging from 1 to 4 times.

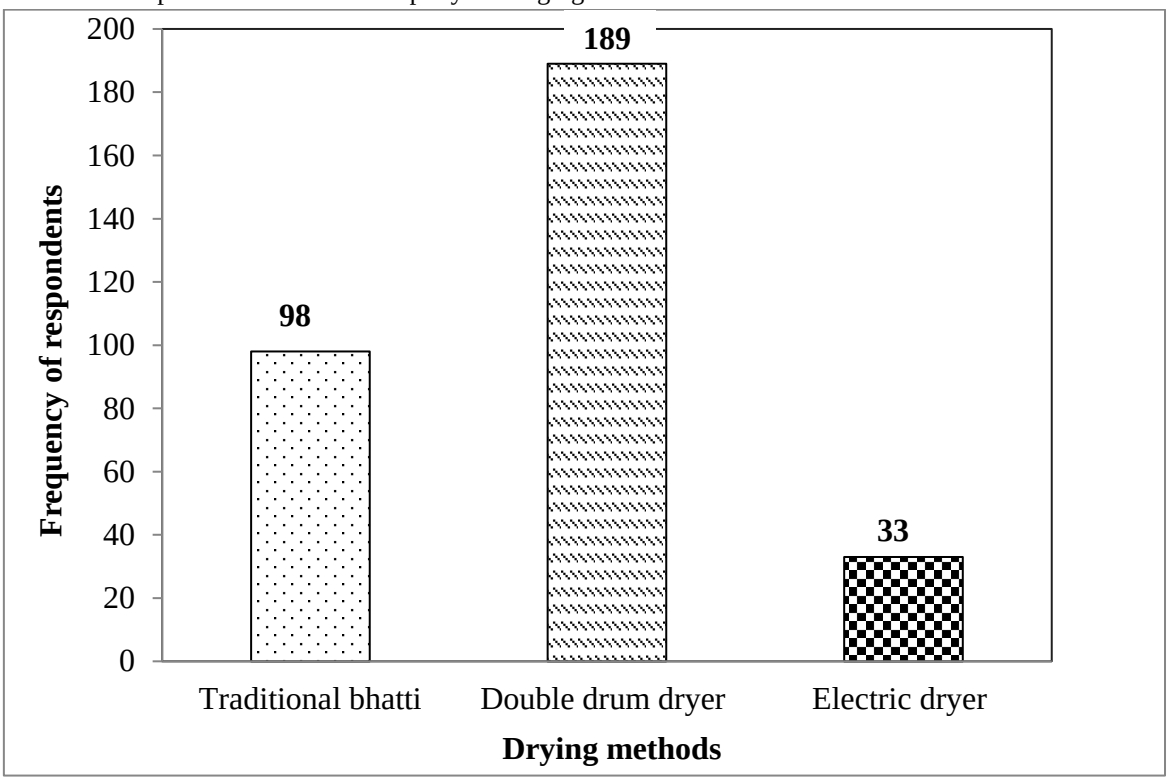

Figure 2: Drying methods adopted by respondents

Storage methods used

In the study area, out of four types of storage methods used for storing dried cardamom capsules by respondent farmers, 129 (40.31%) farmers used jute sacks, 85 (26.56%) farmers used bamboo baskets, 58 (18. 13%) farmers used wooden box and 48 (15%) farmers used black polythene lined (BPL) gunny bag to store dried capsule as shown table 3.

Table 3: Storage methods adopted by respondents

Storage structure adopted	Frequency	Percentage
Black polythene-lined gunny bag	48	15.00
Jute sack	129	40.31
Wooden box	58	18.13
Bamboo basket	85	26.56
Total	320	100.00

Capacity of drying and storage methods adopted

The average drying capacity of the double drum dryer was higher followed by the electric dryer and traditional kiln. Likewise, bamboo baskets had a higher storage capacity of dried capsules followed by wooden boxes, and jute sacks, the least being black polythene-lined gunny bags as shown in table 4.

Table 4: Capacity of drying and storage methods adopted by respondents

Structures	Average capacity (kg)	Minimum value (kg)	Maximum value (kg)
Drying methods adopted			
Traditional kiln	110.61±38.94	100	150
Double drum dryer	282.75±86.35	240	320
Electric Dryer	255.61±78.29	220	280
Storage methods adopted			
Black polythene-lined gunny bag	35.42±9.34	25	50
Jute sack	55.27±14.35	40	70
Wooden box	59.85±18.25	45	75
Bamboo basket	66.78±22.37	50	90

Components of drying and storage benefit

Quantity loss in percentage of drying methods and storage methods adopted

Table 5: Quantity loss in percentage of drying methods and storage methods used by respondents

Methods/methods	Mean	Standard Deviation	F –value	Sig
Drying loss in % of drying structures adopted				
Traditional kiln	13.54	3.84		
Double drum dryer	10.36	2.16	76.495***	.000
Electric dryer	5.95	1.19		
Total	10.78	4.37		
Storage loss in % of storage methods for storing dried capsules for 6 months				
Wooden Box	6.48	1.15		
Bamboo basket	7.92	1.78	5.18**	.0012
BPL Gunny bag	8.05	2.19		
jute sack	6.86	1.43		
Total	7.25	3.39		

The highest drying losses were experienced by farmers using traditional kilns (13.54%) followed by double drum dryers (10.36%) and electric dryers (5.95%) as shown in Table 5. Farmers using wooden boxes for storing capsules for six months experienced the least post-harvest losses (6.48%) due to fewer attacks of insect pests and rodents than other storage methods. This implies that wooden boxes could be an important storage method for ensuring proper storage of dried capsules, particularly for small-scale farmers in developing countries.

Cost of drying and storage methods adopted

The average cost per installment of a traditional kiln was Nepalese rupees (NRs) 135230.61 ranging from NRs 120000 to 150000. Likewise, the double drum dryer and electric dryer's cost of the installment was observed as NRs 192826.75 and NRs 305255.61 respectively as shown in table 6. The average year of functioning of a traditional kiln is 5 years, the double drum dryer is 8-10 years and the Electric dryer is 10-12 years as perceived by respondents.

Furthermore, the average cost of purchasing a black polythene lined gunny bag was found to be NRs 70.42 ranging from NRs 50 to 90. Similarly, the average cost of constructing/purchasing a wooden box was NRs 380.85 ranging from 350 to 450 and that of a bamboo basket was NRs 240.78 with a range from NRs 220 to 310. The average cost of purchasing a jute sack was found to be NRs 90.27 as shown in table 6. In a jute sack and black polythene-lined gunny back, the dried capsule can be stored for one season. The year of functioning of bamboo baskets as perceived by farmers was 2 years while that of wooden boxes was 4 years.

Table 6: Cost of drying and storage methods adopted by respondents

Cost of Structures	Average cost (NRs)	Minimum value (NRs)	Maximum value (NRs)
Drying structures adopted			
Traditional kiln	135230.61±20438.94	120000	150000
Double drum dryer	192826.75±38643.39	165000	220000
Electric dryer	305255.61±47285.26	290500	350000
Storage methods adopted			
Black polythene-lined gunny bag	70.42±19.34	50	90
jute sack	90.27±24.65	70	110
Wooden box	380.85±108.25	350	450
Bamboo basket	240.78±82.37	220	310

Price of dried cardamom capsule

Table 7: Price of cardamom capsules dried from different drying structures adopted by respondents

Cardamom capsule dried from	Average price (NRs)	Minimum price (NRs)	Maximum price (NRs)	F –value	Sig
Traditional kiln	1196.44±74.47	1170	1240		
Double drum dryer	1248.83±92.32	1190	1300	135.18***	0.000
Electric dryer	1283.81±82.34	1220	1350		
Total	1237.86±124.34	1170	1350		

*** signifies significance at a 0.1% level of significance

The average price of the cardamom capsule at the time of drying, dried from a traditional kiln was NRs 1196.44 ranging from NRs 1170 to 1240 as shown in table 7. Buyers prefer capsules dried from an electric dryer because of better aroma, proper flavor and color retention, thus the average price of a capsule dried from an electric dryer was higher at the time of drying that is NRs 1283.81 followed by a capsule dried from double drum dryer as shown in table 18. The differences in the average price of capsules dried from 3 structures were found to be statistically significant at a 0.1 % level of significance.

Quantity of fresh cardamom to produce 1 kg of dried capsule

Table 8 depicts that that the ratio of fresh weight to dry weight is about 4.62, ranging from 4:1 to 5:1 for traditional kilns as perceived by the respondents. It means that on average 4.62 kg of freshly harvested cardamom capsules will yield 1 kg of dried cardamom capsules from traditional kilns. Likewise, in the double drum dryer, the average ratio was found to be 4.74:1 with a range of 4.5:1 to 5.5:1 and from the electric dryer, to produce 1 kg of dried capsule, on an average 5.02 kg (range 4.8 to 6 kg) of fresh capsule should be dried. According to the district rate, the average price of freshly harvested capsules is NRs 50 ranging from NRs 40 to 60 in the study area.

Table 8: Quantity of fresh cardamom to produce 1 kg of dried capsule from three drying structures adopted by respondents

Drying methods	Average quantity of un dried capsule (kg) to produce 1 kg dried capsule	Minimum quantity (kg)	Maximum quantity (kg)
Traditional kiln	4.62±0.34	4.0	5.0
Double drum dryer	4.74±0.56	4.5	5.5
Electric dryer	5.02±0.67	4.8	6.0
Total	4.73±1.54	4.0	6.0

Drying cost

During the drying of freshly harvested cardamom capsules, various costs (both implicit and explicit costs) are incurred. They include transportation and handling costs, labour costs, cost/rent of drying structure, energy costs, depreciation costs, wastage costs (loss during drying), maintenance costs, tax/interest costs and miscellaneous costs (cost of management/arrangement). The table illustrates the drying cost of various drying structures incurred by respondents in the study area. The average drying cost per kg of capsule in a traditional kiln was NRs 476.87 ranging from NRs 450.23 to 576.96. Likewise, in a double drum dryer, the average drying cost per kg dried capsule was NRs 425.58 with a minimum and maximum value of NRs 395.67 and 494.34 respectively. Furthermore, the average drying cost per kg dried capsule from an electric dryer was NRs 356.47 with a range of NRs 337.69 to 389.45 as shown in table 9.

Wastage cost and energy cost account for more than 60% of the total drying cost of capsules dried from all three drying structures. Wastage cost stood first among various costs in the traditional kiln and double drum dryer while energy costs ranked first in electric dryers as shown in table 9.

Table 9: Drying cost per kg of capsule dried in three drying methods

S.N.	Various costs	Average cost in NRs	Minimum cost in NRs	Maximum cost in NRs	Average cost in NRs	Minimum cost in NRs	Maximum cost in NRs	Average cost in NRs	Minimum cost in NRs	Maximum cost in NRs
		Traditional kiln			Double drum dryer			Electric dryer		
1	Handling and transport cost	32.98±4.26	27.41	36.46	34.87±7.24	26.57	40.28	27.78±5.43	23.24	33.28
2	Labor cost	54.29±11.43	39.69	62.24	42.98±8.89	33.26	51.43	32.23±7.98	24.71	41.34
3	Rent/cost of dryer	49.23±9.98	36.44	56.98	50.41±8.84	42.69	59.96	53.25±6.67	45.23	61.24
4	Energy cost	135.21±19.23	108.78	148.24	119.56±18.88	98.56	140.43	113.23±13.37	96.45	123.23
5	Depreciation	6.52±4.32	3.12	11.23	7.63±5.24	3.24	13.36	6.28±3.24	3.07	10.13
6	Wastage cost	156.58±34.61	147.44	190.64	129.49±24.29	113.48	162.46	76.33±9.87	69.61	83.86
7	Tax/interest/ maintenance cost	34.47±8.89	26.34	42.17	32.53±9.35	19.78	38.23	36.63±10.26	25.48	47.45
8	Miscellaneous cost	7.58±1.45	5.37	8.95	8.11±2.48	7.19	10.24	10.85±3.59	9.24	13.65
Total drying cost in NRs		476.87±90.45	450.23	576.96	425.58±68.46	395.67	494.34	356.47±32.23	337.69	389.45
F value	321.437***									
Sig.	.000									

*** signifies significant at 0.1% level of significance

Drying Benefit

The average drying benefit of a traditional kiln was NRs 488.57 ranging from NRs 468.41 to 516.51. Likewise, the average drying benefit of a double drum dryer was found to be NRs 586.23 with a range of NRs 531.32 to 625.22. The highest drying benefit was found in the electric dryer with an average value of NRs 676.34 with a maximum and minimum value of NRs 702.39 and 648.36 respectively. The difference in mean of drying benefit of the three drying methods was statistically significant at a 0.1 % level of significance as shown in table 10.

Table 10: Drying benefit (NRs/kg of dried capsule) of three drying structures adopted by respondents

Drying methods	Mean	Minimum value	Maximum value	F value	Sig
Traditional kiln	488.57±29.87	468.41	516.51		
Double drum dryer	586.23±43.47	531.32	625.22	492.41***	0.000
Electric dryer	676.34±31.43	648.36	702.39		
Total	565.61±82.57	393.41	702.39		

*** signifies significance at a 0.1% level of significance

The maximum drying benefit under farmers' conditions in the study area was found to be NRs 980.97/kg as shown in table 11.

Table 11: Maximum possible drying benefit (NRs/kg dried capsule) in the study area

S.N.	Various costs	Minimum value (NRs/kg)
1	Handling and transport cost	23.24
2	Labor cost	24.71
3	Rent/cost of dryer	36.44

4	Energy cost	96.45
5	Depreciation	3.07
6	Wastage cost	0
7	Tax/interest/maintenance cost	19.78
8	Miscellaneous cost	5.37
Minimum possible drying cost (NRs/kg dried capsule)		209.06
Minimum quantity of fresh capsule to produce 1 kg dried capsule (NRs/kg)		4 kg
Minimum price of 4 kg fresh capsule to produce 1 kg dried capsule(NRs)		160
Maximum price of capsule after drying (NRs/kg)		1350
Maximum possible drying benefit (NRs/kg)		980.94

Drying efficiency

The average drying efficiency of the electric dryer was found to be maximum among three drying methods i.e. 68.95% ranging from 66.09% to 71.60%. Likewise, the average drying efficiency of the double drum dryer was found to be 59.76% with a range of 54.16% to 63.74%. Minimum drying efficiency was found in traditional kilns with an average value of 49.81% with a maximum and minimum value of 53.58% and 44.62% respectively. The difference in mean drying efficiency of the three drying methods was statistically significant at a 0.1 % level of significance as shown in table 12.

Table 12: Drying efficiency (%) of three drying methods adopted by respondents

Drying methods	Drying efficiency (%) Mean±S.D.	Minimum value	Maximum value	F value	Sig.
Traditional kiln	49.81±3.84	44.62	53.58	368.19***	.000
Double drum dryer	59.76±4.52	54.16	63.74		
Electric dryer	68.95±3.67	66.09	71.60		
Total	57.66±9.96	44.62	71.60		

*** represents significant at 0.1% level of significance

Storage cost

Table 13 illustrates the storage cost of four storage methods incurred by respondents in the study area for storing dried capsules for 6 months. From table 13, storage cost was higher in BPL gunny bags and the lowest in wooden boxes in the sixth month of storage. Wastage costs account for more than 65% of total storage costs in all four storage methods.

Table 13: Storage cost (NRs/kg) for storing capsule for six months

Various costs in NRs	Average cost (NRs/kg dried capsule) for storing for 6 months			
	BPL gunny bag	Jute sack	Wooden box	Bamboo basket
Handling and transport cost	8.88±.26	9.06±.29	9.30±.32	9.12±.26
Labor cost	14.21±.83	13.86±.78	13.22±.75	13.81±.98
Rent of storage room	7.38±.48	7.08±.46	6.96±.44	7.62±.48
Cost of storage structure	4.08±.13	4.44±.24	3.84±.21	4.32±.13
Wastage cost	127.62±9.31	108.72±9.43	102.83±9.54	125.53±9.56
Tax/interest/maintenance cost	9.59±.87	9.23±1.09	9.06±1.04	9.52±0.89
Miscellaneous cost	4.13±.84	4.02±.72	3.87±.68	3.89±.83
Total storage cost in NRs/kg	175.89±9.39	156.41±9.45	149.08±9.59	173.81±9.62

Storage benefit and storage efficiency of storage methods

Table 14: Storage benefit (NRs/kg of stored dried capsule) and storage efficiency (%) of four storage methods for storing dried capsule for 6 months

Storage methods	Storage benefit (NRs/kg)	F value	Sig.	Storage efficiency (%)	F value	Sig.
BPL gunny bag	179.12±9.43			46.27±4.01		
Wooden box	205.93±9.68			52.89±5.86	73.19***	.000
Jute sack	198.60±9.52			51.09±5.29		
Bamboo basket	181.20±9.69	185.565***	.000	46.76±3.89		

*** represents significance at a 0.1% level of significance

Table 14 revealed that storage benefit was found to be higher in wooden boxes. However, it was lower in a black polythene-lined gunny bag for six months of storage. The maximum possible storage benefit for storing dried capsules for 6 months in the study area was found to be NRs 385.96/kg as shown in Table 15. Among four storage methods, the average storage efficiency of wooden boxes was found to be maximum for storing dried capsules for six months i.e.52.89% ranging from 49.17% to 56.75%. Likewise, the average storage efficiency of the BPL gunny bag was found to be the lowest among the four storage methods with a value of 46.27% with a maximum and minimum value of 42.26% and 50.23% respectively. The difference in mean storage efficiency among the four storage methods was statistically significant at a 1 % level of significance as shown in Table 14.

Table 15: Maximum possible storage benefit (NRs/kg) for storing dried capsules for 6 months in the study area

Various costs	Minimum value (NRs/kg)
Handling and transport cost	7.18
Labor cost	11.66
Rent of storage room	6.19
Cost of storage structure	3.08
Wastage cost	0
Tax/interest/maintenance cost	7.67
Miscellaneous cost	3.26
Minimum possible storage cost for 6 months (NRs/kg dried capsule)	39.04
Minimum price at the time of drying (NRs/kg dried capsule)	1170
Maximum price of dried capsule stored for 6 months (NRs/kg)	1595
Maximum possible storage benefit (NRs/kg) for storing capsule for 6 months	385.96

CONCLUSION AND POLICY IMPLICATIONS

The study concluded that among all drying and storage methods, a double drum dryer was the most used method for drying freshly harvested large cardamom capsules and a jute sack was the most used storage method to store capsules. Analyzing drying and storage benefits, an electric dryer was the most economical and efficient drying technique for drying freshly harvested cardamom capsules and a wooden box was the most effective for storing dried capsules. The study revealed a promising potential for improving the drying and storage benefits of drying and storage methods of large cardamom in Gandaki province. Since the electric dryer is the most profitable, durable and efficient drying method among the three drying methods in the study area thereby reducing post-harvest losses of the capsule and increasing farm household income effectively, financial assistance such as credit provision to buy an electric dryer and subsidy to farmers should be given to incentivize farmers to adopt electric dryers. The study recommends that farmers should invest in feasible drying and storage methods that ensure effective capsule loss reduction for income generation.

DECLARATIONS

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

The authors would like to thank large cardamom farmers, traders and agriculture experts of the study area for their valuable information.

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