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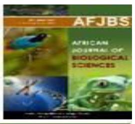

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Technical efficiency of cold storage for potatoes in Farrukhabad district of Uttar Pradesh

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Abstract

The study has estimated technical efficiencies and identified the determinants of technical efficiencies among the potato farmers in the Farrukhabad district of Uttar Pradesh. The data for the study have been collected from its 300 respondents, which include 120 farmers, 30 individuals owning cold storage, and a sample consisting of 60 consumers and 90 traders, using a structured questionnaire and analyzed through a stochastic frontier production function for 2022-2023. The results showed that farmers of potatoes within the zone were experiencing diminishing returns to scale in the utilization of farm inputs. It has also been proved that storage conditions are favorable for the maintenance of potato quality, while low losses can be achieved without using chemicals. The researchers demonstrated how the cold storage techniques reduce costs across the value chain in the product and, therefore, keep the farmer's price competitive. The technical efficiency ranged from 63% to 99%, with a mean of 90%, which showed great potential for productivity growth through better efficiency. The main factors influencing the technical efficiencies are the level of education, experience in farming, off-farm income, and variety of potatoes. The study concluded that policy interventions necessary for enhancing technical efficiency in potato farming in the region should target such determinants.

Keywords: Technical efficiency, Cobb-Douglas, Cold Storage, Potato

Introduction

Potato (Solanum tuberosum L.) remains an essential agricultural food product in the world's agriculture. It is a significant food crop produced and consumed by over 100 countries and more than one billion consumers globally. This versatile tuber is the very heart of the diet of about half a billion people around the world. With its 75% water content, the potato is highly perishable. The high carbohydrate composition gives about 26 g in one medium-sized potato and approximately 80 kcal per 100 g in a fresh potato (Raghuvansi, et al., 2018; Kuyu *et al.,* 2019).

More than just being energy-giving, potatoes are nutritionally dense and contain other vital compounds belonging to both the vitamin and mineral groups, as well as those belonging to the phytochemicals—with carotenoids and polyphenols. The most consumed vegetable in the world, the potato, particularly potatoes with skins, has a fiber content that equals that of many whole-grain products. Among India's states, the potato is cultivated in Uttar Pradesh more than elsewhere, followed by West Bengal, Bihar, Gujarat, and Madhya Pradesh, which account for over 80% of the country's potato production (GOI, 2023).

Although this crop is of high financial importance, acting as a cash crop for Indian farmers, since the potatoes are perishable in nature, this crop fails to enjoy the status of minimum support price from the government (Lamichhane *et al.,* 2019). Therefore, the Indian government has planned numerous ambitious goals for increasing the income of the farmers and promoting agricultural prosperity; for instance, the target entails doubling farmers' incomes by 2022-23 through various welfare schemes and increasing the MSP for major crops tremendously (Chand, 2017). Going ahead, the demand for potatoes is possibly going to soar high; projections are that in 2050, India may require produce close to 125 million tonnes of potatoes from an enhanced farming area of 3.62 million hectares (Vision, 2050). The rising graph of the potato sector is evident from the recent statistics: India produced 54.23 million metric tonnes during 2020-21 from an area of 2.25 million hectares, at a productivity of 24102 kgs per hectare (Agriculture statistics at a glance, 2023). However, post-harvest losses and storage problems, and the fact that technologies have to be resorted to to minimize the losses, highlight the role of effective post-harvest management in the potato sector (Jwanya *et al.,*2014) .

In this study examine to measure the technical efficiency of cold storage for potato by using Cobb Douglas stochastic production function. Many studies have been attempted applied Cobb Douglas stochastic production function for instance, Abedullah et al., 2006 measure technical efficiency and its determinants in potato production, evidence from Punjab. Asogwa *et al.,*2011 measure the economic efficiency of Nigerian small scale farmers: a parametric frontier approach. Wassihun *et al.,*2019 Analysis of technical efficiency of potato (Solanum tuberosum L.) production.

Materials and Methods

The present study was conducted in Farrukhabad district of Uttar Pradesh, India during the 2023-24 cropping season. A multistage stratified, purposive cum random sampling approach was employed to select the study area and respondents.

Data Collection:

The major data were gathered through personally conducted interviews and pre-tested, structured questionnaires. A total of 300 respondents were 120 farmers Purposive cum multistage random sampling technique was used and 30 cold storage, 60 consumer, 90 traders randomly selected from three major potato growing blocks - Mohammadabad, Kamalganj, and Barhpur. Because this district has higher potato production rate and awareness of investigators is high in this district. This sampling approach was chosen to avoid interfering with the investigator's operating convenience. The data collected pertained to the 2022-23 agricultural year and included information on farm size, cropping pattern, land under potato cultivation, resource use pattern, and constraints in production. Data were also collected from traders, commission agents, and processors through personal interviews.

Method of Estimation for Different Post-harvest Losses

The study employed a comprehensive approach to assess post-harvest losses of potatoes at various stages of the supply chain. Field data were collected from different respondents, including farmers, cold storage managers, traders, and consumers, to quantify the losses incurred at different operations and levels.

The sampled potato farmers were directly interviewed to ascertain their total potato production during the 2022-23 cropping season. Regarding post-harvest losses, farmers were asked to quantify the losses encountered at each operation, such as harvesting, curing, and sorting. For instance, if a farmer reported a total production of 2400 kg (60 maunds) and a cutting loss of 18 kg during harvesting, the cutting loss was calculated as (18 kg × 100 / 2400 kg) = 0.75%. Similarly, other post-harvest losses were estimated in terms of the total production to determine the magnitude of losses at each stage.

The study also estimated post-harvest losses for different types of losses, such as weight loss, rotting or spoilage, insect damage, and physical injury. The characteristics of these different types of losses were explained to the respondents, who were then asked to quantify the losses. The individual losses were calculated in terms of total quantity and expressed as a percentage.

It is important to note that the total post-harvest loss cannot be calculated as the sum of the percentages at each loss stage. Instead, the total loss is calculated as follows:

$$\text{Total loss} = z_1 + (100 - z_1) \times z_2/100 + [100 - (100 - z_1) \times z_3/100] + \ldots \quad \ldots\ldots\ldots..(1)$$

Where:

z_1 is the pre-harvest loss (%)

z_2 is the storage loss (%)

z_3 is the loss at the big trader level (%)

and so on for the different stages of the supply chain

This approach ensures a comprehensive assessment of post-harvest losses and provides a more accurate representation of the overall losses experienced in the potato value chain.

Model Description

In this study we have considered the Stochastic Frontier Model to measure the technical efficiency of selected cold storage in Farrukhabad. The framework assumes the existence of a best practice frontier corresponding to fully efficient operation in the industry under investigation. This frontier defines the maximum level of output that can be obtained from any vector of resource inputs in the absence of uncertainty. The stochastic component of the frontier consists of two types of disturbance or error terms. The first is a regular symmetric disturbance that represents statistical noise in a typical regression. The second disturbance or error term, which is firm specific, is a one-sided deviation from this idealized frontier, and is referred to as technical inefficiency. The greater the amount by which the realized production falls short of the stochastic frontier, the greater the level of technical inefficiency (Bauer, 1990; Gene, 1993).

The following Cobb-Douglas stochastic frontier model was used to measure the technical efficiency of cold storage.

$LnY_i = \beta \mathbf{0} + \beta 1 LnX_{1i} + ... + \beta nLnX_{ni} + Vi - Ui$ ……………………….(2)

Where, Y Quantity (good potato) of cold storage output (tons)

X_1= Availability of electricity in 24 hours (hour)

X_2= Outside maximum temperature (°C)

X_3= Storage relative humidity (%)

X_4= Duration of pre-cool period (hour)

X_5=Good quality gunny bags used (%)

X_6= Capacity utilization (%)

X_7= Inversion during storage (number)

X_8=Maturity potatoes stored (%)

X_9=Duration of storage period (month)

The following inefficiency model was used to measure the inefficiency effect of different variables related to manager's and cold storage inherent characteristics.

$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + ... + \delta_n Z_{ni} + W_i$ ………………….(3)

Where, Z_1 = Length of manager's experience (year)

Z_2 = Training received (Received =1, Other = 0)

Z_3= Level of education (schooling year)

Z_4= Power source (PDB=1, REB=0)

Z_5 = Age of the cold storage (year)

Results and Discussion

Post –harvest losses of Cold Stored Potatoes

Description of cold storage

All cold storage have permanent establishment such as land, building with office room, cool chamber, pre- cool chamber, machine room, curing shed, etc. The permanent team includes a manager, accountant, foreman, machine operator, and supervisor. The employees receive a predetermined monthly salary. Contact laborers perform tasks like as loading, unloading, and inversion. These workers are involved in tasks through an intermediary known as a 'Labor member'. The labor representative often establishes communication with the proprietor of the cold storage facility in order to carry out the required tasks during the storage duration. He was compensated by the cold storage owner on a per-bag basis for the tasks of loading, unloading, and inversion. Subsequently, he remunerates the workers on a daily basis.

Typically, there are two categories of clientele who utilize cold storage facilities for storing potatoes: farmers and traders. Traders purchase potatoes from farmers during the harvest season and store them in cold storage facilities in order to obtain a favorable price during the off-season. Approximately 70% of the farmers surveyed in the research areas stored potatoes in cold storage, whereas 30% of the traders examined also utilized this method. Cold storage consumers have two options for utilizing the facility to store potatoes: either through an intermediary or independently. The storage fee varies among the chains. The cost of storing potatoes in cold storage facilities varies among different establishments, but is relatively consistent for all types of users, including farmers and traders. The number of potatoes in a bag varies from user to user. Cold storage authorities often permit a maximum weight of 50 kilograms per bag.

Capacity utilization, related factors and storage loss

Table 1 displays the capacity utilization, storage loss, and other relevant variables of cold storages. Barhpur had the most number of cold storages, with 29 in total, while Mohammadabad had the fewest, with only 12. Kamalganj had a total of 18 cold storages. The mean capacity of refrigerated storage facilities in all regions was 5932.34 metric tons of potatoes. The largest cold storage capacity was discovered in Barhpur, with a size of 6345 tons, followed by Mohammadabad with 5774.00 tons and Kamalganj with 5678.00 tons. Conversely, the smallest cold storage capacity was detected in Kamalganj, also with 5678.00 tons. The overall capacity usage in all sectors was 98.45%, which falls short of the cold storages' intended capacity.

Table 1. Capacity utilization, storage loss and other related factors of cold storages

S.No.	Particulars	Mohammadabad	Kamalganj	Barhpur	Overall average
1.	Available cold storage	12	18	29	19.67
2.	Storage capacity (ton)	5774.00	5678.00	6345.00	5932.34
3.	Capacity utilization (ton)	5707.00 (98.84)	5599.00 (98.60)	6289.00 (99.11)	5861.67 (98.85)
4.	Good potato obtained (ton)	5619.00 (98.45)	5489.00 (98.03)	6191.00 (98.44)	5766.34 (98.30)
5.	Loss during storage (ton)	155 (2.68)	189 (3.32)	154 (2.42)	166 (2.80)
6.	Availability of electricity in 24 hours	18.67	19.11	19.21	18.99
7.	Store temperature (^{0}C)	2.12	1.99	1.95	2.02
8.	Storage RH (%)	86.44	84.26	87.89	86.19
9.	Max. Outside temp. (^{0}C) (April-May)	32.34	31.67	35.66	33.22
10.	Pre- cool period (h)	18.89	14.92	16.45	16.75
11.	Good bag used (%)	89.45	92.65	90.32	90.80
12.	Matured potato stored (%)	88.54	82.33	81.22	84.03
13.	Number of inversion of bag during storage	5.68	4.98	5.19	5.28
14.	Number of bag per stack	5.96	6.47	6.34	6.26
15.	Maximum storage period (month)	8.50	9.02	7.67	8.40

*Note: Figures in the parentheses indicate percentage *Government cold storages were not included in this study*

After a storage period of nine months, specifically from March to November, it was determined that 98.30% of the potatoes that were stored remained in a satisfactory state. The mean potato loss in cold storage over a nine-month period was 2.80% of the total quantity of potatoes stored. The loss can be categorized into three types: weight loss (57%), spoilage loss (34%), and other loss (9%). This loss is mostly caused by factors such as sprouting, shrinkage, and cold injury.

The electric power supply in all study areas is in a critical state. The electricity supply in the research locations had an average duration of 18.99 hours per day, resulting in the cold storage being without power for approximately four hours. The majority of cold storages possessed their own generator to ensure a continuous supply of electricity during periods of load shedding. However, these generators were primarily utilized for lighting purposes. The majority of the generators failed to produce adequate power for the functioning of the cooling machine as a result of their low capacity and voltage of electricity. The storage temperatures in all selected cold storage facilities were consistently below 2.5°C, which is within the recommended temperature range (2-3°C) for holding potatoes in cold storage. However, the clients of the cold storage facility, who are both producers and stockists, have reported that the management of the facility provided inaccurate temperature information. Based on the clients' feedback, the temperature in the cold storage consistently exceeded the recommended level.

The relative humidifies of all cold storages were within the range of 85-88%, which is below the desired value of less than 90%. Many cold storages did not monitor the temperature and relative humidity in the storage chambers directly, but rather obtained this information via the panel board. The average pre-cool period for all the cold storages studied was 18.99 hours, which is less than the mandated minimum pre-cool period of 24 hours. Potatoes should be stored in a refrigerated facility using high-quality packaging. However, around 25% of the occurrences involved the utilization of inferior bags for packaging stored potatoes. The substandard bag contained antiquated bags as well as previously utilized bags of flour and spices. Throughout the storage period, these bags impeded ventilation and rendered potatoes vulnerable to insects and pests, such as rats. Immature potatoes rapidly degrade and are susceptible to heat or cold shocks. The level of maturity of potatoes held in all cold storage facilities was 88.98%. In general, potatoes that are picked early are considered to be immature. The bags in the cold storages were rotated multiple times to ensure even cooling. The mean number of inversions in the examined cold storages was 5.28. The minimum and maximum occurrences of inversions were recorded as three and six times, respectively.

The stack contained a variable amount of bags, ranging from 6 to 7, with an average of 6.26 bags per stack. The storage period commenced in mid-February and concluded in mid-December. The customer was required to remit a specified sum of money as rent to the cold storage facility. He had the flexibility to remove the potatoes from the refrigerated chamber at any moment, but the rental cost remained constant.

Technical Efficiency of Cold Storage

The estimated technical efficiencies of selected cold storage and their frequency distributions are shown in table 2.The maximum, minimum and mean efficiencies were 99 %, 63 % and 90 % respectively. Among the 30 cold storages studied, the efficiencies of four were below 80 %, from 80 to 90 % efficiencies for 7 cold storages, 94 to 97 % for four and 15 cold storages had the efficiencies from 97 to 99 %.

Table 2 Frequency distribution and description statistics of the technical efficiency of cold storage

Level of technical efficiency	**Frequency**	**Cumulative %**
0.63	2	3.33%
0.72	2	6.67 %
0.80	1	8.33%
0.81	3	13.33 %
0.82	2	16.67%
0.88	1	18.33%
0.94	1	20.00%
0.95	1	21.67%
0.97	2	25.00%
More	15	50.00%
Total	30	100.00%
Maximum	0.9998	
Minimum	0.6303	
Mean	0.9070	
Range	0.3667	
Standard Deviation	0.1142	
Standard Error	0.0208	

The Cobb Douglas Stochastic Frontier production Function model was used to estimate the technical efficiency of cold storage and results have been presented in table 3. A total of nine independent variables were used in the model and out of them, five were found to be significant. The coefficient of daily maximum outside temperature and percent of good bag used for packing and storage of potato were both significant at 1 % level. The elasticities of maximum ambient temperature and good bag were 2.09 and 1.53, respectively. It implies that the good potato output increase by 2.09 and 1.53 % if the maximum ambient temperature was decreased and use of good quality bags was increased by 1%.

Table 3 Maximum Likelihood Estimates of the Cobb Douglas Stochastic Frontier Production Function for estimation of technical efficiency of cold storage

Variables	**Parameters**	**Coefficients**	**Standard error**	**t-ratio**
Intercept	β_0	6.3119	3.0265	0.6332
Supply of electricity in 24 hours (h)	β_1	-0.3644***	0.3873	0.0787
Outside max. Temperature (^{0}C)	β_2	0.8487**	0.2713	0.0285
Relative humidity in cool room (%)	β_3	0.2210	0.4562	0.6332
Pre-cooling time (h)	β_4	0.2270***	0.1677	0.0910
Good bag used (%)	β_5	0.6360***	0.4490	0.0720
Capacity utilization (%)	β_6	0.5130	1.5285	0.7406
Inversion of bag (number)	β_7	0.1817**	0.2400	0.0477

Maturity of stored potato (%)	β_8	-0.1587***	0.0883	0.0723
Storage period (month)	β_9	-0.4615	0.3119	0.1391
Sigma-squared	σ^2	0.2173*	0.1566	1.3871
Log likelihood function	-18.2245			

indicates significant (p<0.1), indicates significant (p<0.05) and *** indicates significant (p<0.01)*

Electricity supply and relative humidity inside the store were found to be positive and significant at 5 % level. Hence, the elasticities of electricity supply and relative humidity were 0.84 and 0.18, respectively. For additional 1 % increase of the supply of electricity and increase of the relative humidity, the good potato production would increase by 0.84 and 0.18 %, respectively. The maturity of stored potatoes was found significant at 10 % and its elasticity was 0.21. Output of good potato would increase by 0.21 percent if additional matured potato could be stored. The coefficients of other variables such as pre-cooling period, number of inversion on the production of good potato.

Conclusion

In conclusion, the study on post-harvest losses and technical efficiency of potato storage systems in the Farrukhabad district has revealed that critical variables like electricity supply, relative humidity, and outside temperature greatly influence storage outcomes. The mean technical efficiency was 90%, and the range was 63% to 99%, with excellent possibility of improvement in a cold storage operation. For example, a 1% increase in used bag quality was associated with a 2% decrease in post-harvest losses. These call for a policy intervention such as targeted interventions in improved storage practices, promotion of training, and modernization of infrastructure investments to reduce post-harvest losses and ensure optimization of potato quality—all the while improving the competitiveness and sustainability of the potato industry in the region.

References

Abedullah, B. A. and Bakhsh, K. 2006. Technical efficiency and its determinants in potato production, evidence from Punjab, Pakistan, *Lahore J Econ,* vol.11 no. 2 pp. 1–22, 2006.

Agricultural Statistics at a Glance, Directorate of Economics & Statistics. Government of India, Last accessed, 2023.

Asogwa, B.C., Umeh, J.C. and Penda, S.T. 2011. Analysis of economic efficiency of Nigerian small scale farmers: a parametric frontier approach. *J Econ*, vol. 2 no. 2 pp. 89–98, 2011.

Bauer, P.W.1990. Recent development in the econometrics estimation of frontier, *Journal of Econometrics,* vol. 46, pp. 39-56.

Chand, R. 2017. Doubling farmers' income: Rationale, strategy, prospects and action plan. NITI Policy Paper No. 1/2017. NITI Aayog, Government of India.

Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics, 2023.

Greene, W.H. 1993. The econometrics approach to efficiency analysis, *Oxford University Press, New York*, pp. 68-119.

Jwanya, B.A., Dawang, N.C., Mashat, L.M. and Goijning, B.S. 2014. Technical efficiency of Rain- fed Irish potato farmers in plateau start , Nigeria: A stochastic frontier Approach, *International Institute for Science Technology and education E. journals,* vol. 4, no. 22, pp. 34-39.

Kuyu, C.G., Tola, Y.B. and Abdi, G.G. 2019. study on post harvest quantitative and qualitative losses of potato tubers from two different road access district of Jimma Zone, South west Ethiopia, vol. 5. Pp. 1-7.

Lamichhane, J., Acharya, B. and Sharma, T. 2019. Technical efficiency of potato production in mid western terai region of Nepal, *Journal of Agriculture and Natural Resources,* vol. 2 no. 1, pp. 244-251.

Raghuvansi, A., Gauraha, A.K. and Chandrakar M.R. 2018. Post harvest losses in potato and factors affecting postharvest at farm level in Chhattisgarh, *Journal of pharmacognosy and phytochemistry*, vol. 7, no. 3, pp. 3122-3124.

Vision 2050. Central Potato Research Institute, Indian Council of Agricultural Research, 2015.

Wassihun, A. N., Koye, T.D. and Koye, A.D. 2019. Analysis of technical efficiency of potato (Solanum tuberosum L.) Production in Chilga District, Amhara national regional state, Ethiopia, *Journal of economic structures*, vol. *8*, pp. 1-18.