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An inquest into predictors of losses and constraints in Uttar Pradesh's potato (*Solanum tuberosum*) value chain

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ABSTRACT

A significant portion of total horticultural production is lost each year due to post-harvest losses. These losses vary significantly in different segments of the supply chain and these variations are primarily due to various farm-level factors. Present study was carried out during 2019–20 to isolate the predictors of post-harvest losses in potatoes (*Solanum tuberosum* L.) in the purposively selected Khandoli block of Agra district, Uttar Pradesh. The total sample size was 160 included 120 farmers; 10 wholesalers; 15 retailers and 15 institutional stakeholders. The study used ordered logistic regression analysis and found that the knowledge level of the producers, training received, variety, timely labour availability, quantity harvested, and storage duration influenced the amount of losses in potatoes. The major constraints identified in the potato value chain were small operational size, absence of storage facilities, inadequate insurance coverage and poor market intelligence. The study suggested focusing more on capacity building, breeding & disseminating improved varieties; creating local-level storage infrastructure; ensuring financial risk coverage and price policy support; creating strong marketing intelligence network and farmer mobilization into farmers groups for effective post-harvest management.

Keywords: Constraints, Knowledge, Labour, Ordinal logistic, Potato, Post-harvest losses, Predictors, Regression, Storage

India is the second leading producer of fruits and vegetables in the world after China, accounting for 10% of the total global production. India registered a bumper production of 331.05 million tonnes of horticultural crops. The potato (*Solanum tuberosum* L.) crop, one of the staple diets in our country was grown in an area of 2248 thousand ha in India and recorded production of 54230 thousand million tonnes, according to the third advance estimates for 2020–21 (DAC and FW 2021). The state of Uttar Pradesh is the leading potato producer in India. Given its huge production potential, India is faced with a paradox with respect to the nutritional status of the country. India represents a sorry figure by ranking 101st among 116 nations in the Global Hunger Index 2021, housing the world's highest number of children with severe acute malnutrition (Chandra 2021). According to various studies, nearly 30–40% of fruits and vegetables, amounting to ₹92651 crores, are lost from our total production (Jha *et al.* 2015). Similarly, a significant amount of potato produce is wasted (Kaguongo *et al.* 2014). As a result, it is critical to reduce the losses incurred at various stages of the potato value chain from the standpoints of the economy, food security and nutritional security (Hodges 2011). The leading cause of the massive post-harvest losses is ineffective post-harvest management. To develop effective strategies to reduce post-harvest losses, it is necessary to understand the predictors of losses as well as the factors that prevent farmers from adopting recommended production and post-harvest management practices (Abass *et al.* 2014, Affognon *et al.* 2015, Hengsdijk and Boer 2017). This study attempted to identify the predictors of the post-harvest losses and constraints in the potato value chain in the Agra district of Uttar Pradesh, which can be generalised to similar potato-growing agro-ecological belts.

MATERIALS AND METHODS

The present study was carried during 2019–20 in the purposefully chosen block Khandoli, Agra, Uttar Pradesh based on production figures indicating the highest potato-producing belt. A multistage random sampling procedure was followed to select the respondents from the selected block. From the block, six villages and from each village, 20 potato farmers were selected. Randomly selected 10 wholesalers, 15 retailers and 15 officials from the state

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agricultural department, State Agricultural Marketing Board, KVK-Beechpuri were also included in the study. So, the total sample size was 160 and an ex-post facto research design was used. The responses on the proposed nine predictor variables were gathered by employing a well-structured and pre-tested interview schedule. Ordinal regression is used in situations where we need to predict the dependent variable (post-harvest loss) with 'ordered' multiple categories (low, medium, high) and independent variables. It is used to facilitate the interaction of ordered dependent variables with one or more independent variables.

The ordinal logistic regression model:

$$\text{logit}\,[P(Y \leq j)] - \log\left[\frac{P(Y \leq j)}{P(Y > j)}\right] - \alpha j - \beta X,\ j \in [1, J-1]$$

where $j \in [1, J-1]$, levels of the ordinal outcome variable Y. The proportional odds model assumes there is a common set of slope parameters β for the predictors. The ordinal outcomes are distinguished by the J−1 intercepts α_j. The benchmark level is J. Here, the constraints were classified as technical, infrastructural, marketing, and financial. The scoring pattern was as follows: 1 (least severe), 2 (not so severe), 3 (moderately severe), 4 (severe), and 5 (extremely severe) (most severe). The mean score for each constraint was computed and ranked accordingly.

RESULTS AND DISCUSSION

Losses were classified as low, medium, or high based on the mean and standard deviation of total post-harvest losses incurred by the respondents (Table 1). The independent variables in the econometric model were tested for multi-collinearity and found to fit the model because the variance inflation factors were less than 5 (Table 1). The statistical significance of the model and the non-significant Pearson χ^2 test statistics (Table 1) indicated that it is a better fit than the baseline model with no predictors. The variables could explain 45% of the variation in potato losses. The assumption of proportional odds was met, as evidenced by the non-significance result of the test of parallel lines. Farm size had no significant influence on the amount of post-harvest loss in potato. The knowledge level was significantly influencing the post-harvest losses as hypothesized. The log odds of incurring high post-harvest losses increased by 0.284 for persons with low knowledge level and by 0.198 for persons with medium knowledge level as compared to those with high knowledge on good management practices (GMPs). Association with experience was found negative but not significant, in accordance with Ortmann and King (2010), Martey (2012), Maremera (2014), Tadesse *et al.* (2018). Training on post-harvest handling was found to positively and significantly influence the amount of losses.

Table 1 Results of regression model on the predictors of potato loss at farm level (n=120)

Independent variable	Estimate	Std error	P-value	VIF	Tolerance
Farm Size	0.020	0.015	0.206	1.50	0.666
Knowledge (Low = 1)	0.284**	0.354	0.033	1.39	0.719
Knowledge (Medium = 2)	0.198**	0.334	0.031		
Knowledge (High = 3)	0[a]	-	-		
Experience	-0.003	0.519	0.119	1.48	0.675
Training (No training received = 0)	0.014***	0.519	0.009	1.47	0.680
Training (Training received = 1)	0[a]	-	-		
Variety (Local variety = 0)	0.145*	0.088	0.091	1.40	0.714
Variety (Improved variety = 1)	0[a]	-	-		
Timely Labour availability (No = 0)	0.031***	0.024	0.010	1.21	0.826
Timely Labour availability (Yes = 1)	0[a]	-	-		
Quantity harvested	0.146***	0.232	0.006	1.23	0.813
Storage duration	0.055***	0.043	0.001	1.16	0.862
Distance from farm to market	0.004	0.091	0.181	1.08	0.925
Model fit	$\chi^2(9) = 65.458$, p = 0.007				
Goodness of fit (Pearson)	$\chi^2(198) = 197.484$, p = 0.22				
Pseudo R-square (Nagelkerke)	0.451				
Test of parallel lines	$\chi^2(9) = 14.656$, p = 0.346				
Distribution of respondents on the basis of losses					
Post-harvest loss (q/ha) in potato	Frequency (%)			Mean = 41.39; Standard Deviation = 14.56	
Low (<26.83)	30 (25)				
Medium (26.83–55.95)	58 (48.14)				
High (>55.95)	32 (26.67)				

*, **, *** means the coefficient is statistically significant at 10, 5 and 1% levels, respectively.

The farmers using improved potato varieties were incurring decreased losses due to the inherent trait of higher shelf-life than the counterparts growing local varieties. The results were consistent with Hirpa *et al.* (2010), Musita *et al.* (2019) who also reported that the cultivation of varieties with longer shelf-life and disease resistance could effectively influence and reduce the post-harvest losses.

Lack of timely availability of labour was significantly affecting the level of post-harvest losses. It was expected that the greater the quantity of produce harvested, the greater the losses. With a unit increase in quantity harvested, there is a predicted increase of 0.146 in the log odds of reporting higher post-harvest losses. This was reiterated by the findings of Ortmann and King (2010), Ayandiji *et al.* (2011) and Maremera (2014) that the higher production volumes imply higher losses since farmers face the constraints of limited storage facilities and poor handling practices. However, the findings contrasted that of Takane (2008), who argued that production volume might help the farmers to achieve economies of scale and overcome the credit market, thus reducing the post-harvest losses. As the number of days increased between harvesting and selling the produce, the potato farmers were more likely to report higher post-harvest losses. The same finding was reiterated by Nema *et al.* (2008), who found that the longer storage periods under poor storage conditions increased the likelihood of greening, sprouting, and developing glycoalkaloids in the tubers. Extended storage time at an ambient environment resulted in high average weight loss, significant loss in firmness, and average vitamin C content (Kuyu 2019). The distance from farm to market showed a positive but statistically insignificant relationship with post-harvest losses. Ortmann and King (2010), Ayandiji (2011), Kereth *et al.* (2013), Maremera (2014) and Tewodros *et al.* (2014) also reported the influence of the market distance on the quantum of the post-harvest losses due to build-up of temperature and mechanical injuries in transit in different commodities like potato, cabbage, tomato.

Tadesse *et al.* (2018) found variables like gender, distance to market, experience, family size, area of cultivation, the volume of produce, selling price, and access to credit, to significantly determine the amount of post-harvest loss in potato, whereas the factors which were not significantly associated were access to extension service, improved seed, age, and education level. The findings confirmed to those reported by Kereth *et al.* (2013) that the distance of the market, age of the horticultural produce, the experience of the grower, availability of transportation, and road links significantly influence the post-harvest losses. Mbuk *et al.* (2011) also reported the market distance, method of transportation, and inadequate infrastructures as the major determinants of post-harvest losses in fruits and vegetables.

Constraints faced in the potato value chain: The farmers pointed out their small operational land holdings as the most severe constraint hindering the adoption of various post-harvest management activities (Table 2). They perceived that extension support from state agricultural departments about improved technologies was weak and needed further improvement. Equally, the severe constraint was the unavailability of skilled labour to carry out necessary and time-bound procedures, which was also confirmed by Raghuvanshi *et al.* (2018). Within the infrastructural constraints, the farmers considered lack of storage and processing facilities at the local level, leading to massive wastage. If any, the cold storage facilities were charging high prices per bag. Many farmers didn't have access to essential equipments like moisture meters and weighing machines. The government agencies could meet only 10% of the total seed demand while others were procured from private sources or used their own saved seeds. Shee *et al.* (2019) reported that prior training, transportation, and storage significantly influenced post-harvest management decisions. The need for proper storage facilities on modern and cost-effective lines was heavily emphasized by Musita *et al.* (2019) to reduce the post-harvest losses. Though the study did not identify the lack of transportation facilities as a significant issue in the study area, Ayandiji *et al.* (2011) stated that transportation issues are a major impediment in the value chain of perishable agricultural commodities.

The most severe financial constraints were inadequate insurance coverage and unawareness of insurance facilities. 80% of the respondents were unaware of the existing insurance facilities. Many complained of inadequate insurance coverage, faulty calculation, and lower compensation for crop losses. According to Sharifuddin *et al.* (2015) the major constraints reported by farmers and officials were high initial investment, lack of government procurement, high storing charges, low market price of potato, untimely quality seed supply and high price of pesticides. Lack of market intelligence was regarded as the most severe marketing constraint. Farmers did not have an exact idea of the existing current market demand, arrivals, ongoing market prices and thus, could not plan their post-harvest activities accordingly and faced market risk and uncertainty. Second constraining factor was unawareness about required FAQs (Fair Average Quality standards) and market specifications. Secondary processing of potatoes can take various forms like flakes, powder, chips, french fries, namkeen, dehydrated potato, canned potato, frozen foods (wedges, pancakes, patties, puffs), etc. However, it was discovered that secondary processing was not widely performed. High initial investment required was the major impediment followed by lack of government support, which was complicated further by the complex procedures of availing the existing schemes. Farmers also feared stiff competition from already established brands in the market and difficulties in obtaining certification for the required quality standards of the processed products. However, there was no scarcity of raw materials, and timely availability was also not an issue. In addition, there was a high demand for processed products in the study area. The current findings corroborate the findings of Mebratie *et al.* (2015), Bantayehu *et al.* (2017) and Sahu *et al.* (2021).

The study reported that the major predictors of post-

Table 2 Constraints faced in potato value chain (n=160)

Particular	Mean	SD	Rank
Technical constraints			
Economically unviable operational size	4.23	0.89	I
Unavailability of skilled labour	4.08	1.01	II
Complexity and difficulty in following the recommended practices	3.00	0.80	IV
Varietal specificity of the post-harvest technologies	2.40	1.09	V
Lack of extension support & guidance	4.08	0.93	II
Lack of training of farmers on PHM handling	3.92	0.88	III
Infrastructural constraints			
Shortage of abundant clean water supplies	2.47	0.96	IV
Lack of proper inputs, chemicals, equipments	3.80	0.73	III
Lack of storage facilities	3.80	0.99	III
Lack of processing facilities	4.52	0.61	II
Lack of cold storage facilities	4.60	0.64	I
Lack of transportation facilities	2.33	0.89	V
Financial constraints			
High cost of inputs and chemicals	4.33	0.65	III
High cost of skilled labour	4.27	0.78	IV
High initial investment in infrastructure	1.97	0.84	VIII
High payback period in investment	1.83	0.83	IX
Lack of awareness of credit availability	1.52	0.60	X
Lack of access to institutional credit facilities	3.98	1.01	VI
High interest rate for credit	3.77	1.21	VII
Lack of govt. support (credit, subsidy)	4.05	0.70	V
Unawareness of insurance facilities in case of risk	4.47	0.73	II
Inadequate insurance coverage	4.53	0.90	I
Marketing constraints			
Distress sale of produce- need of immediate liquid cash	3.72	1.04	V
Lack of market intelligence	4.65	0.55	I
Lack of demand for value-added products by local customers	1.17	0.38	VIII
Competition with existing private players	1.72	0.72	VII
Low knowledge of marketing strategies	3.77	1.21	IV
Lack of price policy by the government	3.50	1.14	VI
Lack of group approach	4.18	0.77	III
Meeting the quality standards & specifications	4.38	0.72	II
Constraints for secondary processing in potato			
Low risk-taking ability	2.42	1.03	VIII
Lack of training and know-how on the subject	3.12	1.12	VI
Lack of uniformity and quality of raw materials	2.84	0.79	VII
Lack of sufficient quantity of raw materials	1.70	0.76	X
Round the year availability of raw materials	1.84	0.74	IX
Inadequate infrastructural (storage) facilities	4.14	0.70	IV
High initial investment	4.65	0.55	I
High payback period	4.08	0.88	V
Lack of price policy by government	4.60	0.64	II
Complexity in availing govt. schemes	4.60	0.59	II
Lack of local demand	1.60	0.67	XI
Competition with private players	4.52	0.61	III
Difficulty in maintaining quality standards and obtaining certification	4.52	0.68	III

harvest losses in potatoes were the level of knowledge, training received, variety, labour, quantity harvested, and storage duration. So, the government can devise a careful mix of various interventions like capacity-building programmes, exposure visits, demonstrations and mass media interventions to equip farmers with knowledge of advanced PHM technologies. Also, filling up vacancies for grass-root extension workers should be taken up on priority to ensure wider reach to farmers. There is an increased need for funds for research and development of climate-resilient improved varieties with enhanced disease resistance, shelf life and nutrition. etc. Government should intervene in farm gate price fixation and direct procurement as in rice and wheat. Processing units and cold storages should be established in public-private partnership mode to channelise the season's surplus produce, minimise wastage and benefit from off-season sales.

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