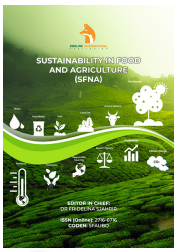
ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2716-6716 (Online)
CODEN: SFAUBO

Sustainability in Food and Agriculture (SFNA)

DOI: http://doi.org/10.26480/sfna.02.2020.88.94



RESEARCH ARTICLE

STORABILITY OF POTATO VARIETIES UNDER ORDINARY STORAGE CONDITION IN PANAUTI, NEPAL

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ARTICLE DETAILS

Article History:

Received 13 April 2020
Accepted 15 May 2020
Available online 10 June 2020

ABSTRACT

This study was conducted with the objective of assessing post harvest losses of potato varieties under farmers' storage conditions. Potato tubers of 7 varieties (4 released varieties *viz.* 'Janakdev', 'Khumal Upahar' Khumal Ujjwal and 'Khumal Vikash'; 2 registered varieties *viz.* 'Cardinal' and 'MS - 42.3' and a local cultivar *viz.* Panauti Golo) were evaluated in randomized complete block design with four replications under four farmers' storage condition at Panauti-8, Kavrepalanchok district of Nepal during May 24 to Ausgust 11, 2019. Data were recorded on 20, 40, 60 and 80 days of storage. Observations were recorded on average weight loss, damage by tuber moth, days to sprouting, sprout length, days to shrinking, and damage due to rotting. The results showed that at 80 days of storage, the lowest weight loss (8.31%) was found in 'Khumal Ujjwal' followed by 'Janakdev' (8.74%) and 'Panauti Golo' (8.85%). Tthe difference between number of eyes and infested eyes was minimum in 'Panauti Golo' (1.65). Llate sprouting was observed in 'Panauti Golo' (68.5 days) and 'Khumal Upahar' (68.2 days). The shortest sprout length (2.3 cm) was recorded in 'Panauti Golo'. Shrinkage was late in 'Panauti Golo' (79 days) and 'Jankadev' (75.8 days).No damage by potato tuber moth was observed in the flesh of 'Panauti Golo' and 'Khumal Upahar'; however external infestation was detected in their eyes. Therefore, local cultivated variety 'Panauti Golo' was promising for its shelf-life in farm condition; which can be recommended for commercial production in mid-hill environment of Nepal.

KEYWORDS

weight loss, shrinkage, sprouting, storability, potato tuber moth.

1. INTRODUCTION

Potato is one of the most important vegetable crops in Nepal. It occupies the fifth position in area coverage, second in total production and first in productivity among the food crops (rice, wheat, maize finger millet and potato) grown in Nepal (NPRP, 2018). Its yield is lower than other neighboring countries. In 2018, the yields of potato in Bangladesh, Bhutan, China, India, Netherlands and USA were 20.4, 10.6, 18.8, 22.6, 36.6 and 49.8 mt/ha; respectively (FAOSTAT, 2020). Recent data showed that the area, production and productivity of potato were 195,173 ha, 2,881,829 tons and of 14.7 t/ha, respectively in the year 2017/18 (MoALD, 2019). Of this yield, considerable amount of potatoes is lost during post harvest handling and storage. Post-harvest losses of potato was estimated about 24% in India, 20 percent in Bangladesh and 25 percent in Nepal (Karki, 2002; Prasad et al., 1989; Satter et al., 2002). It was observed that about 6% loss was during post-harvest handling and marketing in Chattisgarh India (Raghuvanshi et al., 2018).

In Nepal, about 40 percent of this loss was estimated in potato (Khairgoli, 1998). In a recent report, losses during post-harvest storage of potato ranged from 15-20% (Bhattarai, 2018). Disciplines of Nepal Agricultural Research Council (NARC) such as National Potato Research Programme (NPRP) and Entomology Division have developed some technologies for reducing post-harvest losses; however, their promotion to farming communities is inadequate (Gautam et al., 2016; Giri et al., 2016). Post-harvest loss of potato in farm condition is an important issue in Nepalese potato industry. Potato contains higher moisture as compared to grains so its long term storage is difficult even in cold storage, where a loss of 8-10 % is incurred during the storage period of 7-8 months (Gautam, 2016). Total post-harvest losses of potato at market level in Ethiopia was estimated about 5.95 kg/100 kg out of which contribution of losses at storage level was 1.18 kg/100 kg (19.79% of the total loss) (Raghuvanshi et al., 2018). In several supply chain stages, in average 12.08 % of the potato tubers are lost per hectare (Kuyu et al., 2019). Reduction of Post-harvest losses is a considerable component of ensuring future global food security (Aulakh et al., 2013). In this context, reducing post-harvest losses seems to be an option to make more foods available without increasing pressure on the natural resources (Hodges et al., 2011).

In Nepal, the possible causes of post-harvest losses were sprouting during room storage, infestation of Potato Tuber Moth (PTM) *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae), weight loss, and limited

Quick Response Code	Access this article online	
	Website: www.sfna.org.my	DOI: 10.26480/sfna.02.2020.88.94

Cite the Article: Kalika P. Upadhyay, Neela Paudel, Sunil Aryal, Resona Simkhada, Bikash Bhusal, Ishwori P. Gautam (2020). Storability Of Potato Varieties Under Ordinary Storage Condition In Panauti, Nepal. *Sustainability in Food and Agriculture, 1(2): 88-94.*

technical knowledge of the farmers (NPRP, 2018). For instance, potato tuber moth alone can cause 100% infestation in untreated potato in local unrefrigerated stores (CIP, 1988; Joshi, 1989; Aryal and Jung, 2015). The potato growers of Kavrepalanchok district of Nepal were also facing the problem of considerable loss of potato under ordinary storage condition since many decades (Upadhyay et al., 2016). The main causes of post-harvest loss in these areas were varieties with short post-harvest life, early sprouting, tuber rot, shrinkage and infestation of potato tuber moth. Thus, the problem of post-harvest losses could be solved through the utilization of varieties with long post-harvest shelf life. The present study explains how the potato varieties performed at farmers' storage condition without any chemical treatment.

2. Materials and Methods

2.1 Study area description

An experiment was conducted by National Potato Research Program (NPRP) at Panauti-8, Panauti in Kavrepalanchok district. Panauti is situated at 27^{0} 34' 58'' N and 85^{0} 30'' 34' E with the altitude of 1232-1500 masl while experimental site was in 1330 masl, 1 km south from Panauti market. It is 32 km southeast from capital Kathmandu. Its climate is a subtropical type where three crops of potatoes can be grown in a year. However, September-October-November and February-March are main planting seasons. Potatoes are harvested 90-120 days after planting depending on the maturity of the varieties. Temperatures are high in summer and rainy seasons April-August) while humidity is high in rainy season (July-August-September) and low in remaining part of the year. Farmers store potatoes in ordinary room condition with proper windows ventilation. Farmers generally store potatoes in heaps on the floor.

2.2 Potato varieties for experiment and their arrangement

This experiment was conducted to select appropriate variety with long Post-harvest shelf-life. Experiment was undertaken in a randomized complete block design with 4 replications in four farmers' storage rooms. The experiment consisted of 7 varieties among them 4 were released varieties viz. 'Janakdev', 'Khumal Ujjwal', 'Khumal Upahar' and 'Khumal Vikash'), 2 were registered varieties viz. Cardinal and MS - 42.3 and a local cultivar was 'Panauti Golo'. The varieties were popular in different regions of the country but were new in Panauti area except 'Janakdev' and 'Panauti Golo'. Detail of the varieties is presented in the Table 1a and 1b. This study was so important in Panauti that this was Super Zone of Potato in the country from where large amounts of potato were sold to Kathmandu, other markets in the country and India.

Table 1a: Potato varieties used as the treatments for the experiment

Varieties	Original Name	Source	Status
Cardinal[1]	Tulner/De Vries 54-30-8 x SVP 55-89	Holland	Registered
Janakdev[3]	CIP-720123 [Atzimba x Desiree]	CIP	Released
Khumal Vikash[2]	PRP 25861.1 [Desiree X LBr 40]	Nepal	Released
Khumal Ujjwal[3]	L-235-4	CIP	Released
Khumal Upahar	CIP 389746.2	CIP	Released
MS - 42.3[3]	MS 42.3	Nepal	Registered
Panauti Golo[4]	Panauti Golo	Nepal	Local

([1]ECPD, 2010; [2]Upadhyay, 2018; [3]Upadhyay, 2017; [4]Upadhyay et al., 2016)

Table 1b: Features of potato varieties used as the treatments for the experiment

Variety	Skin color	Flesh color	Shape	Eye depth	Maturity days	Yield t/ha[4]
Cardinal[1]	Red	Cream	Long to oval	Shallow	90-110	20-25
Janakdev[3]	Red	Yellow	Long	Medium	110-130	25-30
Khumal Vikash[2]	Red	Cream	Round to oval	Shallow	90-110	25-30
Khumal Ujjwal[3]		Cream	Round	Medium	110-130	20-25
Khumal Upahar[3]	White, red eyes	Cream	Round	Deep	110-130	25-30
MS - 42.3[3]	purple blue	yellow	Long	Shallow	90-110	25-30
Panauti Golo[4]	Red	Yellow	Round	Medium	90-110	15-20

([1]ECPD, 2010; [2]Upadhyay, 2018; [3]Upadhyay, 2017 [4]Upadhayay, 2016)

Potato varieties were harvested in 2nd week of May, 2019 when they reached at their harvesting maturity. Storage experiment was conducted on May 26, 2019 and continued to August 13, 2019 (80 days). Immediately after harvesting, the tubers were spread and allowed to curing for 2 weeks and to form periderm. Twenty seed sized tubers (25-50 g size) of each variety were selected for the experiment. Jute pieces were spread on the floor before keeping tubers on them. Varieties were arranged randomly and separated with wooden stick. The tubers were red, purple blue or white in color while their flesh color was either yellow or cream. Similarly, the shape of tuber was long, round or oval depending on the nature of the varieties. Shallow, medium and deep eyed tubers were selected with their maturity level counting the days after planting like early (<90 days), medium (90-100 days) and late (110-130 days).

2.3 Storage parameters

Daily maximum and minimum temperatures were recorded with the maximum and minimum thermometer while dry and wet bulb thermometer readings were used to calculate the relative humidity. The thermometer records were taken at 6 am every day. Data were recorded on 20, 40, 60 and 80 days of storage. Observations on average weight loss, infestation by tuber moth, days to sprouting, sprout length; shrinkage behavior and damage due to rotting were recorded. Weight loss was calculated by deducting periodic weights of tubers from the initial weight at the time of storage and was expressed in percent using the following formula:

$$Weight\ loss\ \% = \frac{Initial\ weight\ at\ the\ time\ of\ storage - weight\ on\ the\ recorded\ date}{Initial\ weight\ at\ the\ time\ of\ storage}\ X\ 100$$

Tubers infested with PTM were recorded with the number of infested eyes in the tuber. Days to sprouting were counted when at least one sprout was appeared in 50% of tubers. Sprout length was measured on 80 days of storage. Total sprout lengths of randomly selected 5 tubers were averaged. Days to shrinking were also counted when at least 50% of tuber surface of 50% tubers was shrunk. Number of rotted tubers was recorded at the time of each recording. Data were managed in spreadsheet and analyzed with Genstat version 18 software for windows (VSN International, 2015). Analysis of variance was used to determine statistically significant differences between means. Post hoc analysis was done by Duncan's Multiple Range Test. Least significant differences were determined for all significant data and correlation coefficient was calculated to find out the relationship between the parameters.

3. Results and Discussion

3.1 Temperature and relative humidity of the site

The weather of Panauti was summer during the experimental period. Temperatures and humidity were higher than the requirement of potato storage. For potato storage, ideal room temperatures should be between 42 and 50^{0}F (5.5-10^{0}C) (Woodwell et al., 2009). Maximum temperatures of Panauti ranged from 19.6^{0}C to 29.6^{0}C while minimum temperatures varied from 11.4^{0}C to 16.9^{0}C (Table 2). Similarly, Relative humidity ranged from 72% to 96%. Relative humidity figures were lower in initial 4 weeks than the latter indicating the dry spell during May in pre-monsoon period. In latter weeks, humidity was within the range of requirement of potato. The ideal relative humidity for storing potato is 90-95% (Woodwell et al., 2009).

Table 2: Temperature and relative humidity of the experimental site

week	Temperatures (°C)		Relative humidity (%)
	Maximum	Minimum	
1	21.6	14.9	77
2	29.6	16.2	72
3	25.9	13.9	72
4	28.4	13.8	75
5	27.9	16.9	91
6	19.6	11.4	95
7	22.9	13.6	78
8	23.5	13.9	86
9	24.6	14.9	91
10	24.4	13.2	91
11	24.9	11.7	90
12	24.6	13.4	96
13	23.4	13.1	96
14	23.4	13.9	86
15	22.6	15.1	82
16	20.0	15.8	90

3.2 Storage parameters

3.2.1 Average weight loss

Significant differences were observed for average weight loss between the varieties when they were stored for 20, 40, 60 and 80 days of storage (F-probability = <0.001 in all recordings; CV% = 14.3, 16.7, 16.7 and 21.2; and LSD = 0.887, 1.612, 2.249 and 3.633; respectively) at 5% level of significance. In 20 days, the percent of weight loss ranged from 2.19 (Janakdev) to 7.04 (MS - 42.3) (Figure 1). According to post hoc test (Table 3), varieties cardinal, Khumal Vikash, Khumal Upahar and Panauti Golo showed similar performance. In 40 days, the loss was the greatest (11.02%) in MS - 42.3 and the least (3.19%) in Janakdev. Remaining varieties were significantly different from MS - 42.3 and Janakdev but they had statistically similar performance. In 60 days, the highest weight loss (17.68%) was observed in MS - 42.3 and the lowest (6.60%) in Janakdev.. Varieties Janakdev, Khumal Vikash and MS - 42.3 were significantly different for their weight loss while Janakdev, Cardinal, Khumal Ujjwal, Khumal Upahar and Panauti Golo showed statistically similar performance. In 80 days, MS - 42.3 had the highest (23.01%) weight loss while it was the lowest (8.31%) in Khumal Ujjwal. Except MS - 42.3, all tested varieties had statistically similar weight loss on 80 days of storage. In a previous study, average weight loss of potato was about 15.3-17.9% in retailers' storage condition during 30 days of storage (Kuyu et al., 2019). The degree of weight loss during storage relies on genotype which was also linked to the present study (Patel et al., 2002). A group researcher reported that late maturing potato varieties had good storability which was also true in our experiment (Pandey et al., 2000). In the experiment Panuti Golo, Janakdev, Khumal Ujjwal and Khumal Upahar were late maturing varieties. In an experiment conducted in India, three cultivars stored at room temperature (24 - 36°C) from mid-March to mid-May in which the weight loss in K. Surya was lower (9.1%) compared to controls varieties K. Bahar and K. Jyoti (12 - 13%) (Ezekiel et al., 2004).

According to a study, Varieties differ in weight loss pattern which agreed to the results of present study (Hardenburg, 1949). The author further explained the difference in weight loss occurred from transpiration. Our finding is in line with the work that moisture is lost during storage due to respiration and transpiration (Tigist et al., 2013). The work undertaken in Kenya also proposed the similar observation on storage related losses (Kaguongo et al., 2014). In another experiment conducted, weight loss was 26.4% at 10°C due to excessive sprout growth; with minimum weight loss in potatoes stored at 4°C and maximum in those stored at 10°C (Ezekiel et al., 2007). Similarly, at 120 days of ambient storage significantly less weight loss was recorded in genotypes Yagana (12.3%) and L-235.4 (14.7%) followed by K. Jyoti (16.1%) and Khumal Seto-1 (16.5%) (Gautam et al., 2016). Potato varieties stored at room temperature for 105 days showed that K. Chipsona-2 recorded higher weight loss than K. Pushkar, K. Surya and K. Chipsona-1, indicating variation between varieties in their weight loss in the same storage environment (Mehta et al., 2006).

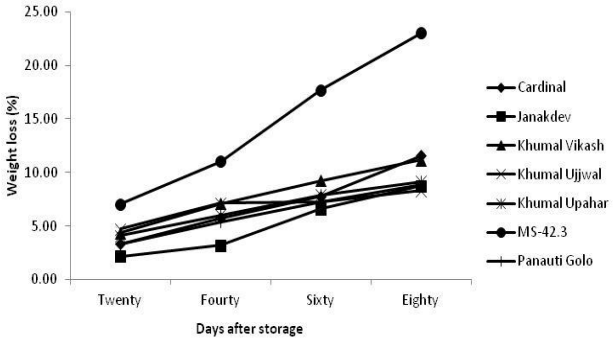

Figure 1: Average weight loss of potato varieties under ordinary storage condition in Panauti, Nepal

Table 3: Post hoc test for group comparison of weight loss percent

Varieties	20 days	40 days	60 days	80 days
Cardinal	3.34 ± 0.26 b	5.76 ± 0.08 b	7.75 ± 0.33 ab	11.59 ± 0.43 a
Janakdev	2.19 ± 0.20 a	3.19 ± 0.48 a	6.60 ± 0.50 a	8.74 ± 0.48 a
Khumal Vikash	4.38 ± 0.29 bc	7.09 ± 0.40 b	9.22 ± 0.05 b	11.15 ± 0.20 a
Khumal Ujjwal	4.72 ± 0.22 c	7.13 ± 0.81 b	7.26 ± 0.45 ab	8.31 ± 0.68 a
Khumal Upahar	4.12 ± 0.59 bc	6.02 ± 0.41 b	7.91 ± 0.73 ab	9.16 ± 0.43 a
MS - 42.3	7.04 ± 0.40 d	11.02 ± 0.68 c	17.68 ± 1.78 c	23.01 ± 3.09 b
Panauti Golo	3.35 ± 0.26 b	5.40 ± 0.47 b	7.21 ± 0.57 ab	8.85 ± 0.44 a

The ± values represent standard error of the mean. The values followed by same letters in the same column are not significantly different.

3.3 Damage by PTM

Number of eyes per tuber (F probability = 0.001, CV% = 12.0 and LSD = 1.098) and number of infested eyes per tuber (F probability = 0.052, CV% = 17.2 and LSD = 1.398) were significantly different between varieties (α = 0.05). Average number of eyes per tuber ranged from 5.0 (Khumal Ujjwal) to 7.5 (Panauti Golo) (Figure 2). Panauti Golo and Cardinal were statistically similar in terms of number of eyes per tuber. The potato tuber moth infested the largest number of eyes (6.8) per tuber in Cardinal while the smallest (4.8) number of infested eyes was in Khumal Upahar. Humal Ujjwal and Khumal Upahar were statistically similar in terms of number of infested eyes by PTM.

The difference between number of eyes and infested eyes was greater (1.65) in Panauti Golo while it was the least (0.1) in MS - 42.3. It was observed that the tubers of Panauti Golo and Khumal Upahar were infested by the pest on the surface only. We cut the tubers to observe the mining trend of the pest into the tuber. It showed a large part of the flesh of these varieties was edible after peeling. The larvae of potato tuber moth had mined into the tubers of MS - 42.3 and Cardinal till the time of last recording (80 days of storage). The results indicated that the pest infested the tubers of Panauti Golo and Khumal Upahar and either it did not prefer the taste of the flesh or repelled by the tubers smell.

Potato varieties may express different level of resistance/tolerance to the feeding preferences of the pest which was also observed in our study (Sharaby et al., 2014). Larval penetrations into the tuber may vary in varieties and with the peel of the tuber which may act as a barrier to the first instar larvae establishment (Fenemore, 1980). We found that the peel of less infested varieties was damaged but penetration was not extended to the flesh. Eyes number were related to vulnerability of the tubers towards PTM (Das et al., 1993). Variation between potato varieties in terms of the infestation may be attributed to different levels of sugar or glycoalkaloid and amino acid contents (Yathom, 1968). The glycoalkaloids, amino acids and digestible carbohydrate should be determined in the tested varieties; however they were not tested in the present study. The mechanism of resistance of varieties to potato tuber moth was most probably antibiosis (Ojero and Mueke, 1985).

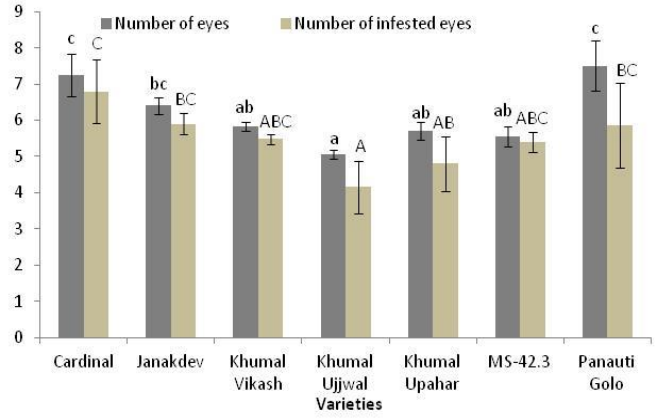

Figure 2: Mean Infestation pattern of potato varieties by potato tuber moth. Bar represent ± SE. Same letters above bar indicate no significant difference.

Plate 1: Image showing varied response of varieties to PTM infestation on 80 days of storage

3.3.1 Correlation of number of eyes and number of infested eyes by PTM

The correlation coefficient between number of eyes and number of infested eyes showed a positive relationship (towards +1) between these two parameters in all tested varieties indicating a strong correlation coefficient (r = >0.5) for all varieties (Table 4). The *P* value for the correlation coefficient of variety 'Cardinal' showed statistically significant at α = 0.05; indicating that there was significant increase in infested number of eyes when the number of eyes is higher in the tubers of variety Cardinal (Table 4). The *P* values for other varieties were not significant; however, the experiment *P* value was significant for correlation coefficient of these parameters. The result indicated that the number of eyes is important for infestation of potato by PTM.

Table 4: Correlation between number of eyes and number of infested eyes due to PTM

Varieties	r	*p* value
Cardinal	0.97	0.03
Janakdev	0.61	0.39
Khumal Vikash	0.73	0.27
Khumal Ujjwal	0.75	0.25
Khumal Upahar	0.51	0.49
MS - 42.3	0.94	0.06
Panauti golo	0.88	0.12
Experiment	0.78	<0.0001

3.4 Days to sprouting

There were significant differences (F probability = <0.001, CV% = 1.9 and LSD = 1.720) for days to 50% sprouting between the varieties (α = 0.05). An early sprouting (38.2 days after storage) was observed in the variety MS - 42.3 while it was late (68.5 and 68.2 days after storage) in Panauti Golo and Khumal Upahar, respectively (Figure 3). Except the variety MS - 42.3, tubers of other varieties sprouted between 57-68 days of storage. Sprouting was not occurred in all varieties till 20 days of storage. The results indicated that all varieties could be stored in ordinary room storage for 30 days without any treatment against sprouting. According to a researcher, varieties are characterized by different sprouting behavior which also agreed to the results of present study (Hardenburg, 1949). We found differences in days to sprouting due to the effect of variety, but other reports defined as function of genetic material, stage of tuber, environment, management conditions, temperature, humidity, water supply, photoperiod etc. (Mani and Hannachi, 2015). Variation in sprouting is related to cultivars which was linked to our results (Hay and Porter, 2006; Carli et al., 2010).

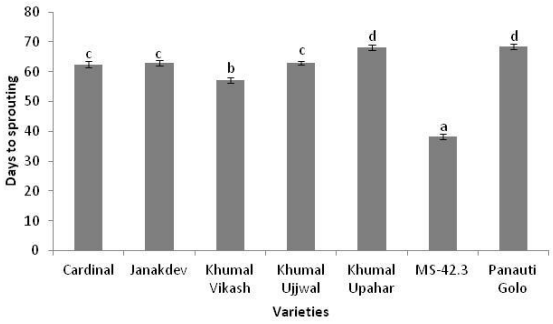

Figure 3: Days to sprouting of potato varieties. Bars represent ± SE. Same letter above bars indicates no significant difference

3.5 Sprout length

Significant differences (F probability = <0.001, CV% = 8.4 and LSD = 0.531) were observed between varieties for their mean sprout length (α = 0.05). The total sprout length ranged from 2.3 to 5.6 cm on 80 days of storage. The longest sprouts (5.6 cm) was observed in the variety MS - 42.3 while it was the shortest (2.3 cm) in Panauti Golo followed by 3.5 cm in Khumal Vikash (Figure 4). Total sprout length was the longest in variety MS - 42.3 (5.6 cm) followed by Cardinal (4.9 cm). It would be noteworthy that the seeds sprouted in 80 could be used for September planting as three planting seasons are in practice in Panauti. In previous reports, average sprout length of varieties was 7.8 cm when they were stored for 90 days in Baglung district without any treatment (Giri et al., 2020). According to another study, storage of 2-3^{o}C followed by storage at high temperatures suit for sprouting (Wurr and Allen, 2009). In our study, temperatures were higher than these from the time of harvesting to the end of the experiment.

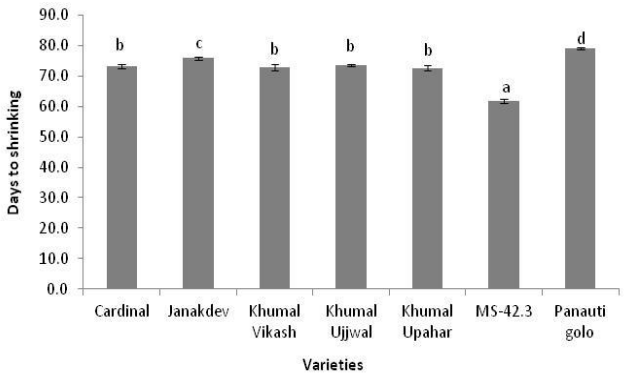

Figure 4: Sprout length of the varieties on 80 days after storage. Bars represent ± SE. Same letter above bars indicates no significant difference

3.5.1 Correlation of weight loss, number of infested eyes by PTM and sprout length

Correlation test was done to determine the contribution of tuber infestation by PTM and sprout length to weight loss of potatoes. The results revealed that there was a positive relationship between weight loss and number of eyes infested by PTM as well as weight loss and sprout length (Table 5). Correlation coefficients of individual varieties implied that an increase in number of infested tubers and sprout length can positively contribute to weight loss; however the p values for the correlation coefficient of weight loss and number of eyes infested by PTM for all individual varieties and experiment were not statistically significant (>0.05) except for Khumal Vikash (*P* = 0.02) and Khumal Upahar (*P* = 0.03). Similarly, the *P* values for the correlation coefficient of weight loss and sprout length for all individual varieties were not statistically significant (>0.05) except for Khumal Ujjwal (*P* = 0.04) and experiment (*P* = 0.03).

Table 5: Correlation coefficient (r) and p value for weight loss versus PTM infestation and sprout length

Varieties	Weight loss and # of eyes infested by PTM		Weight loss and sprout length	
	r	*P* value	r	*P* value
Cardinal	0.68	0.32	0.88	0.12
Janakdev	0.75	0.25	0.68	0.32
Khumal Vikash	0.98	0.02	0.81	0.19
Khumal Ujjwal	0.82	0.18	0.96	0.04
Khumal Upahar	0.97	0.03	0.19	0.81
MS - 42.3	0.86	0.14	0.72	0.28
Panauti golo	0.19	0.81	0.86	0.14
Experiment	0.09	0.65	0.54	0.03

3.6 Days to shrinking

Days to shrinking was recorded when 50% of tuber surface of 50% of the tubers was shrunk. The results revealed that there were significant differences (F probability = <0.001, CV = 1.6 and LSD = 1.705) between varieties for days to 50% shrinking. However, no shrinkage was observed in all varieties till 40 days of storage. Thereafter, the variety MS - 42.3 started shrinking and 50% of its tubers showed shrinkage on 61.8 days of storage (Figure 5). The latest shrinking (79 days of storage) variety was Panauti Golo followed by Janakdev (75.8 days after storage). In these two varieties, their flesh was still edible as shrinking effect was minor and, on the surface, only.

Rests of the varieties were statistically at par for days to shrinking. Loss of moisture through transpiration should have played a significant role in shrinkage. The transpiration should also be related to the relative humidity lower than 90% during early storage period and temperatures higher than 10 ^{0}C throughout the experimental period (Table 2). The variety started early shrinkage had also greater weight loss percent (Figure 1), damage by potato tuber moth and sprouting (Figure 3).

Therefore, the shrinkage behavior was obvious in the variety with significant weight loss, sprouting and damage by the pest. Mining of tubers by PTM would be an important factor responsible for early shrinkage because the tubers of MS - 42.3 were infested deeper into tuber while surface infestation was observed in Panauti Golo and Khumal Upahar on 80 of storage (Plate 1). Similarly, variety Cardinal had higher infestation. Panauti Golo and Khumal Upahar were still edible after peeling the infested surface. A group researchers reported that as firmness lost, wilting and wrinkling happens due to moisture loss from the commodities (Siddiqui et al., 2011).

Decrease in firmness also expected during storage of tubers due to increased metabolic and enzymatic activities thereby starch and cell wall degradation (Page et al., 2008). Hardenburg pointed out that 75% shrinkage was due to moisture loss and 25% due to sprouting (Hardenburg, 1949). The Deformations and loss of volume were the result of loss of water and heating (Ramos et al., 2003; Mayor and Sereno, 2004; Frias et al., 2010). According to Mulet et al. (2000), shape had an influence on the dimensional shrinkage of potatoes. The views also reported in line with linear relationship between shrinkage parameter and moisture content (Hassini et al., 2007; Rahman and Kumar, 2007). In the present study, the shrinkage was the function of temperature, relative humidity, weight loss, sprouting and damage by potato tuber moth.

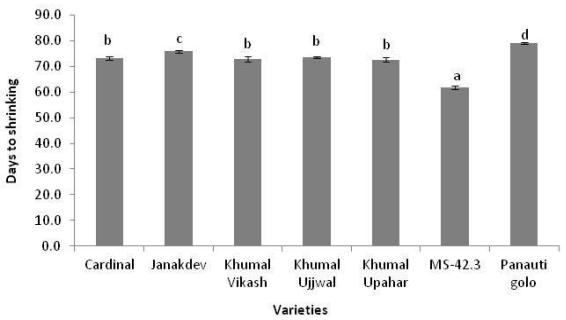

Figure 5: Days to shrinking for tested potato varieties. Bars represent ± SE. Same letter above bars indicates no significant difference

3.7 Loss due to rotting

No loss of tubers was observed due to rotting during the experimental period. Rotting is mainly caused due to dry rot, soft rot and other fungal diseases. Storage environments influence the host pathogen interaction (Masum et al., 2011). In the present experiment, storage rooms were well-ventilated, and tubers were spread on the floor in a single layer. Tubers were free from bruising or other damages. In a previous study, loss of 3.95, 0.91 and 0.69 % of tubers was occurred due to soft rot, dry rot and scab diseases (Masum et al., 2011).

The authors also emphasized that yield losses attributed to dry rot in storage ranged from 6 to 25% in some cases. Similarly, about 4.9% average loss of potato was recorded due to bacterial soft rot at farmer's level in Bangladesh (Rahman et al., 2010). In present experiment, storage environment of Panauti was appropriate and less prone to rotting.

Conclusion

Popular variety MS-42.3 had a short shelf life. It should be used for fresh consumption. The Local cultivate variety 'Panauti Golo' and a released variety 'Khumal Upahar' showed less Post-harvest losses for 80 days of storage at famers' storage condition. 'Panauti Golo' is high yielding but limited to Panauti area. This variety should be tested in other similar locations and recommended for mid-hill region of Nepal.

Acknowledgement

Authors would like to acknowledge the Korea International Cooperation Agency (KOICA) and United Nations Development Program (UNDP) for funding this activity under the Value Chain Development Project in Nepal. The Present study was an activity of a project 'Scaling up of sustainable technologies for reducing post-harvest losses of potato in corridors of Prithvi and B.P. highways of Nepal' implemented by NPRP. We also thank Nepal Agricultural Research Council for coordinating for the grant provided by Value Chain Development Project. We also thank those farmers who actively participated in the experiment.

Author Contributions

Kalika Prasad Upadhyay developed project activity and designed and managed the experiment, Neela Paudel actively involved experimentation process, data recording and management, Sunil Aryal, Resona Simkhada and Bikash Bhusal were mainly involved in entomological scoring part and also helped in whole experimentation process. Ishwori Prasad Gautam guided research and logistics.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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Cite the Article: Kalika P. Upadhyay, Neela Paudel, Sunil Aryal, Resona Simkhada, Bikash Bhusal, Ishwori P. Gautam (2020). Storability Of Potato Varieties Under Ordinary Storage Condition In Panauti, Nepal. *Sustainability in Food and Agriculture, 1(2): 88-94.*