2018). Losses of tomato greatly affect the post-harvest value chain in Nepal. It has short life span of usually 2-3 weeks; increasing the storage life and improvement of tomato fruit quality is really desirable (Sammi and Masud, 2007). Hence, the study is carried out to assist minimization of losses and prolong the shelf life of tomato in Mid-hills of Nepal.

3. OBJECTIVES OF THE STUDY

The objective behind carrying out this very research includes:

➢ To prolong the shelf-life of tomatoes using different polymeric plastic packaging

➢ To determine the different post-harvest quality parameters of tomatoes as affected by the different polymeric plastic packaging.

4. MATERIALS AND METHODS

The study was conducted at the Horticulture Laboratory of Gokuleshwor Agriculture and Animal Science College, Gokuleshwor, Baitadi. It lies in the longitude 80^0 50' East and latitude 24^0 75' North and elevation of 700masl.

4.1 Preparation of experiment samples & Observations taken

Freshly harvested defect-free green stage tomatoes of Manisha variety were washed in freshwater and were allowed to dry for about 2 hours to remove the field heat. Two samples of each containing half kg tomatoes was taken foe each treatment; one destructive sampling and the remaining non-destructive one. There were 5 treatments which is elaborated below and these treatments were replicated four times viz. R1, R2, R3 &R4. This makes total number of samples 40 (every treatment two samples, every replication five treatments and number of replication 4). Every sample was packed in respective plastic of the given treatments while control or no packaging was weighed to half kg and left open in tray. Rubber band was used to seal the mouth of polythene to restrict the air exchange only from the holes made. 4 holes of 4mm diameter in each plastic package were made with a heated wall nail in order to facilitate air exchange. Observations were made for weight, TSS, TA, PH and Firmness. Non-destructive sample was only used for weight while all other parameters were taken from destructive sampling. The parameters were recorded in every 4 days. Samples were kept in the different plastic tray at lab condition.

Table 1: Temperature (in ˚C) and Relative Humidity (%) recorded on respective days of research

Days of Observation	1st	5th	9th	13th	17th	21st
Temperature (˚C)	15	13.9	13.5	15.2	14.9	13.8
Relative Humidity (%)	59	66	66	65	59	66

4.2 Experimental design and treatments

The experimental set up was done in Completely Randomized Design (CRD) with five treatments of different plastic packaging, each replicated four times.

Treatments detail

T_1 : No packaging/open (Control)
T_2 : Ordinary white plastic
T_3 : 38 micron Polypropylene (PP_{38})
T_4 : 38 microns Low-Density Polyethylene ($LDPE_{38}$)
T_5 : 25 microns Low-Density Polyethylene ($LDPE_{25}$)

4.2.1 *Percentage of weight loss*

It was calculated as the percentage weight loss of the initial weight. The initial weight of each sample per replication was taken before packing. The weight of the sample was taken on four days interval after setting of the experiment. The formula used for the calculation was:

$$\text{weight loss\%} = \frac{\text{initial weight} - \text{Final weight}}{\text{Initial Weight}} \times 100$$

4.2.2 *Firmness and Total soluble solid (TSS-^{0}Brix)*

The firmness of the samples was measured with the help of a penetrometer at four days interval after the initiation of the experiment. The Total Soluble Solid (^{0}Brix) was determined by a handheld refractometer. A drop of juice was squeezed from the fruit sample on the prism of the refractometer and TSS content was recorded.

4.2.3 *Titrable acidity (TA)*

TA was determined by the titration method, using standardized 0.1% NaOH solution and phenolphthalein indicator. TA was quantified by titrating 5 ml of tomato juice (obtained by squeezing the fruit) with NaOH solution and expressed as % of citric acid.

$$\text{Total Titrable Acidity}(\%) = \frac{N_B \times V_B \times \text{Milliequivalent wt. of predominant acid} \times 100 \times \text{d.f}}{\text{Volume of sample}}$$

Where, N_B = Normality of base (NaOH)
V_B = Volume of the base
d. f. = Dilution factor
Milliequivalent wt. of predominant acid i.e. citric acid = 0.064

4.2.4 *pH of fruit juice and color change*

The pH of the fruit juice was measured by using an automatic digital p^H meter from the juice extracted for titration. It was evaluated by visual observation by comparing the sample fruit color with the standard color chart.

4.3 Data analysis

Data entry and analysis was done by using a computer software package, Microsoft Excel (2007) and R (agricolae v.1.3-2)

5. RESULTS AND DISCUSSION

5.1 Physiological loss in weight

Table 2: Effect of packaging material on physiological loss in weight (%).

Treatments	Physiological loss in weight (%)				
	5th day	9th day	13th day	17th day	21st day
No packaging	4.06^c(0.61)	5.49^b(0.74)	7.21^c(0.85)	9.29^c(0.97)	13.25^c(1.12)
Ordinary Plastic	1^a(0)	1.18^a(0.07)	1.26^a(0.10)	1.34^a(0.13)	2.18^a(0.34)
PP_{38}	1.16^a(0.06)	1.26^a(0.10)	1.59^a(0.20)	1.67^a(0.22)	1.20^a(0.30)
$LDPE_{38}$	2.11^b(0.32)	2.11^a(0.32)	2.78^b(0.44)	3.08^b(0.49)	3.39^b(0.53)
$LDPE_{25}$	1.22^a(0.09)	1.22^a(0.09)	1.38^a(0.14)	1.38^a(0.14)	1.92^a(0.28)
Grand Mean	0.216	0.265	0.349	0.389	0.515
LSD	0.2364**	0.2332**	0.1910**	0.1992**	0.1456**
CV (%)	72.5	58.5	36.4	33.9	18.8
SEM	0.16	0.15	0.13	0.13	0.10

Means with same letter (letters) within column do not differ significantly at p=0.05 by DMRT

PP_{38} = Polypropylene (38 micron), $LDPE_{38}$ = Low density Polyethylene (38 micron), $LDPE_{25}$ = Low density Polyethylene (25 micron), SEM = Standard error of means, LSD = Least significant difference, CV = Coefficient of variance, * significant at 1% and ** significant at 5% level of significance and value in bracket represents transformed value.

There is a significant difference among different types of packaging in days of packaging (Table 1). Among the different treatments, no packaging (open) showed significantly the highest percentage of weight loss whereas the lowest percentage of weight loss was observed in ordinary plastic which was statistically at significant with PP_{38} and $LDPE_{25}$. Physiological weight loss is one of the major factors which determines the shelf life of tomato. The weight loss of fresh tomatoes is primarily due to transpiration and respiration (Singh, 2010). Transpiration loss is due to the vapor pressure difference between the atmosphere and the transpiring surface. When the tomatoes stored without any packaging (open) in the laboratory, the transpiration and respiration will be more, and higher weight loss can be observed.

5.2 Total soluble solid (TSS)

Table 3: Effect of packaging materials on TSS content of tomato

Treatments	Total soluble solids (TSS)			
	1st day	5th day	9th day	13th day
No packaging	3.65^{a}	3.78^{a}	4.03^{a}	4.33^{b}
Ordinary plastic	3.60^{a}	3.73^{a}	3.75^{a}	3.85^{ab}
PP_{38}	3.15^{a}	3.43^{a}	3.6^{a}	3.83^{ab}
$LDPE_{38}$	3.25^{a}	3.50^{a}	3.63^{a}	3.88^{ab}
$LDPE_{25}$	3.15^{a}	3.43^{a}	3.55^{a}	3.75^{a}
Grand Mean	3.36	3.57	3.72	3.93
LSD	NS	NS	NS	0.35^{*}
CV (%)	11.0	8.9	8	5.9
SEM	0.37	0.32	0.30	0.23

Means with same letter (letters) within column do not differ significantly at p=0.05 by DMRT

PP_{38} = Polypropylene (38 micron), $LDPE_{38}$ = Low density Polyethylene (38 micron), $LDPE_{25}$ = Low density Polyethylene (25 micron), SEM = Standard error of means, LSD = Least significant difference, CV = Coefficient of variance, * significant at 1% and ** significant at 5% level of significance.

There is no significant difference in TSS value among different types of packaging at the 1st, 5^{th,} and 9thday of packaging (Table 2). At the final day of storage i.e. research termination day (13th day), no packaging (open) showed significantly highest TSS content (4.33^{0}Brix) and lowest TSS content was observed in$LDPE_{25}$ (3.75^{0}Brix). This may be due to a slower rate of respiration and metabolic activities that retard the ripening process in packed tomatoes as compared to the open storage (Gharezi et al., 2012). Although the results are statistically non-significant, from the initial stage of packaging open treatment i.e. no packaging showed the highest TSS content and among the different packaging materials used, ordinary plastic packaging showed the highest TSS content. The more TSS content the more ripened is the fruit. Tomatoes with higher TSS content are preferred for consumption but the rapid increase in TSS content indicates the progression of maturity and decreases the shelf life of the commodity. Hence, a slow increase in TSS content is suitable for prolonging shelf life.

5.3 Titratable acidity (TA)

Graphical study of change in titratable acidity (TA) percentage in different packaging materials showed a slight decrement from 1st day to 5th day of packaging and then increases from 5th day to 13th day of packaging. In no packaging (open) treatment, from 1st day to 5th day there was a decrease in TA percentage (from 0.75% to 0.64%) and from 5th day to 9th day TA percentage was increased (from 0.64% to 0.71%). Then after reaching to 13th day the TA percentage was again increased (from 0.71% to 1.00%).

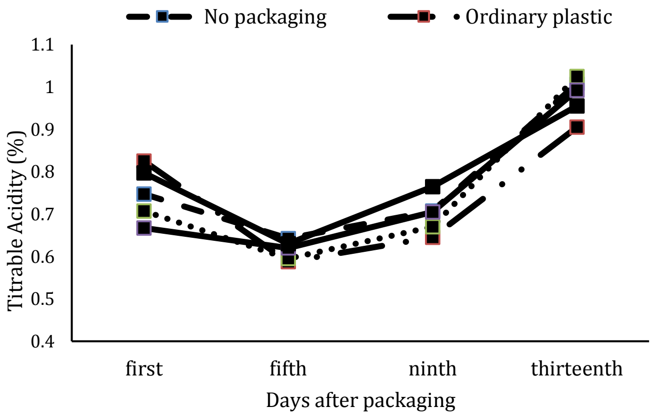

Figure 1: Effect of packaging materials on TA (%) of tomato at various days after packaging

5.4 pH

At the initial stage of packaging the pH is highest in the PP_{38} (4.4) and lowest was in the ordinary plastic (4.05) but on the last day of storage highest pH was observed in $LDPE_{25}$ (4.46) and lowest was observed in PP_{38} (4.39). When the fruit progress towards ripening the TA percentage goes on decreasing it means the pH value goes on increasing in the fruit. Fruit having a lower TA percentage can be considered more ripened than that having a higher TA percentage. Titratable acidity denotes the maturity period of tomato. In general, titratable acidity decreases towards maturity but the graph shows it is decreased at first then slightly increased at the end of the research. A similar type of observation was recorded by who observed a decrease in TA at first up to 5 days of storage and then increases slightly up to 11 days (Gharezi et al., 2012).

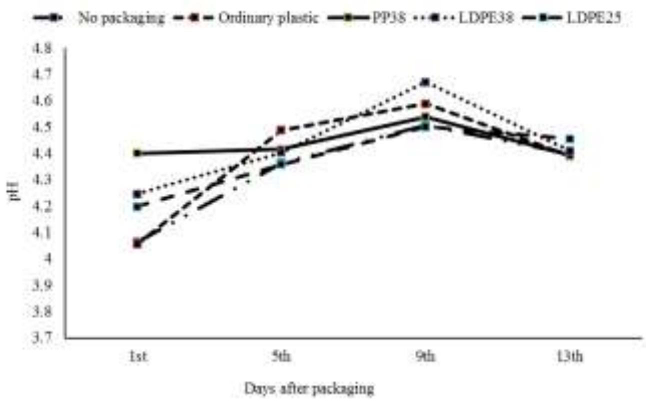

Figure 2: Effect of packaging materials on pH of tomato at various days after packaging

5.5 Firmness

The below bar diagram showed a gradual decrease in tomato fruit firmness as the storage time increases in the case of all the packaging materials used. Highest firmness was observed in ordinary plastic (4.06) and the lowest was observed in no packaging (3.35) but they are not statistically different from each other. All the treatments are statistically at par on the final day of storage for firmness. The ripened tomato fruit is softer than unripe fruit which means ripened fruit has the lowest firmness value than unripe. Among the different treatments on the last day of data collection i.e. 13th day, highest firmness was observed in ordinary plastic (4.06) that has decreased from 4.54 from the first day.
The rate of decrease in firmness value being slower in this packaging can be considered better than other packaging materials. Softness in tomato fruits is caused by the degradation of pectic substances. Pectic substances degradation results in drastic changes in texture with an increased softening of the tomato tissues (Vu et al., 2004). The pectin degradation enzymes are sensitive to oxygen. The availability of more oxygen increases the rate of pectin degradation which results in the softness of fruit. That's why the softening process is slower in packed tomatoes due to the lack of more oxygen (Maddison and Shepherd, 1985).

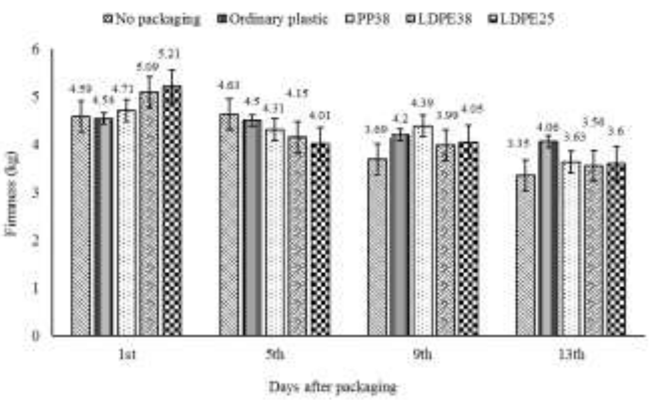

Figure 3: Effect of packaging materials on the firmness of tomato at various days after packaging

6. CONCLUSION

Packaging fundamentally affected the postharvest characteristics (weight reduction, pH, TSS, firmness, and TA) and tomato self-life of realistic usability was reached out in packaged commodities. From this experimentation, it is presumed that the Packaging affected decidedly the tomato quality. Decreased weight and, and short self-life were seen in unpackaged tomatoes while packed had built up a strong self-life and low weight loss. Difference in pack construction, Temperature and Relative Humidity not being effective, non-uniformity in tomatoes size included in pack could be the reasons for not observing the significant differences among the different treatments. Since the results were statistically non-significant among packaging material, using ordinary plastic was concluded for efficient storage of tomatoes fruit increasing their postharvest life in the sub-tropical climate of Nepal. The reason for considering ordinary plastic as the best packaging material is because of its lower price and easy availability in the local market of Nepal

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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