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# Effect of hot water treatment and packaging methods on physiological quality of potato tubers stored at room temperature

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**Abstract**
The cured tubers of variety Kufri Chipsona-4 were subjected to the sprout inhibiting treatment viz., hot water dip treatment (57.5±0.1 ºC for 20 min). The control (untreated) and treated potato tubers were packed either in nylon mesh bags or MAP (modified atmosphere packaging) or vacuum packaging and stored at room temperature (RT) (32±2 ºC; RH ~90%). The tubers were stored for 5 weeks at RT conditions and sampled at 7-day interval. A progressive increase in sprouting, PLW (Physiological loss in weight); and decrease in firmness of potato tubers was observed during storage. Hot water dip treated tubers showed significantly lower sprouting, PLW and higher firmness than untreated tubers. Among various packaging methods, vacuum packaged tubers had significantly lower sprouting, while maximum sprouting was observed in modified atmosphere packaging. PLW of tubers was lower in vacuum packaging, while maximum tuber weight loss was observed in net bag packaging.

**Keywords:** Kufri chipsona-4, room storage, hot water dip (HWT), potato, packaging methods, modified atmosphere packaging

## Introduction
Potato (*Solanum tuberosum* L.), a short duration annual crop is nutritionally superior and capable pf producing high amount of food per unit area in given time (Mehta and Singh, 2015) [10]. UNESCO (United Nations Educational, Scientific and Cultural Organization) declared 2008 as the 'International Year of Potato' calling it 'food of the future' and 3rd most important world food crop. Potato is perishable in nature and requires adequate storage temperature for availability throughout the year. There are frequent cases of mismatch between demand and supply of potatoes due to scanty unevenly distributed and expensive refrigerated storage facilities leading to losses for farmers (Kaur *et al*. 2009) [6].
Potato starch industry depends on stored potatoes for uninterrupted supply. The aim of long term storage is to prolong dormant period and retard deterioration and inhibit sprouting in potato tubers to get optimum starch quality (Ezekiel *et al.*, 2010; Golmohammadi and Afkari-Sayyah, 2013) [3, 4]. Storage of potatoes is done in heaps (short-term) (Mehta *et al.*, 2011) [9] and at 12°C with CIPC (long-term) (Ezekiel *et al.*, 2008) [2]. But information on shelf-life and post-harvest losses of commercial potato cultivars under ambient conditions (20- 35°C, 44-86% RH) is unavailable. Potatoes are cured prior to storage by holding them at low temperature and high relative humidity for 10-15 days to heal minor cuts and bruises and thicken the skin.
Vacuum packaging with low temperature and Modified atmosphere packaging have been shown to increase the shelf-life of potatoes, retain tuber firmness, reducing sugar content and color (Rocha *et al.*, 2003; Shetty *et al.*, 1989) [13, 15]. Use of chemicals like CIPC, irradiation and heat treatments has been shown to inhibit sprouting of tubers and also alter their biochemical properties (Lu *et al*., 2012; Ranganna *et al*., 1998) [7, 11].

## Material and methods
The present research work was carried out at Centre of Food Science and Technology, CCSHAU, Hisar. Potatoes (*Solanum tuberosum* L.) of white flesh varieties Kufri Chipsona-4 were procured from Vegetable Farm, CCS HAU, Hisar. All chemicals were procured from Sigma-Aldrich Chemicals Pvt. Ltd., New Delhi (India) and Central drug House (CDH), New Delhi (India).

## Storage treatments

**Hot water dip treatment:** Potato tubers were washed thoroughly in distilled water, patted dry and eight tubers per sample were taken. Tubers were immersed for 20 min in a 45 L water bath maintained at 57.5±0.1 °C. Tubers were immediately cooled in distilled water at ambient temperature for 10 min and air dried. Washed and untreated tubers were taken as control.

**Packaging:** Potatoes were packaged in three different packaging: net bags, passive modified atmosphere (MA) packaging and vacuum packaging with 8 tubers (~1 Kg) each pack.

**Net bags:** A batch of hot water treated and control potatoes were packed in net bags having length 41.4 cm and breadth 29.6 cm.

**Modified atmosphere packaging:** A batch of hot water treated and control potatoes were packed in LDPE bags having length 31.5 cm, breadth 25.5 cm and thickness 100 micron (400 gauges). The bags were sealed with sealing machine.

**Vacuum packaging:** A batch of hot water treated and control potatoes were placed in LDPE bags having length 31.5 cm, breadth 25.5 cm and thickness 100 micron (400 gauges). They were packed in LDPE bags with a Multivac machine (1 mBar for 10 s).

## Storage conditions

Packed tubers were placed in corrugated fiberboard boxes and stored at room temperature (32±2 °C and RH 90%) for 5 weeks. Sampling was done at 7-day intervals.

## Observation recorded

**Sprouting percentage:** The stored potatoes with buds (eyes) length more than 0.5mm were counted as sprouted potatoes.

$$\text{Sprouting (\%)} = \frac{\text{Number of sproted potatoes}}{\text{Initial number of healthy potatoes}}$$

**Physiological loss in weight (PLW) percentage:** At the beginning i.e. 0th day of the storage, weight of potato was recorded (initial weight). On the day of observation, the stored potatoes were again weighed (final weight).

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

**Firmness:** Flesh firmness for potato was measured by hand held fruit pressure tester (TR Agricoli, Italy; Model FT 327) using cylindrical plunger of 8 mm diameter and firmness scale of 13 kg/sq cm. Firmness was measured from the equatorial region after removing 1 mm thick peel with the help of a sharp knife. Firmness was measured in $kg/cm^2$ and average of 8 tubers per treatment was recorded.

## Statistical analysis

The data obtained in the present investigation were subjected to statistical analysis of variance (ANOVA). Means were separated by critical difference (CD) at 5% level of significance. For this experiment three factorial CRD was used for analysis using OPStat software, CCSHAU, Hisar.

## Results and Discussion

### Sprouting

The effect of sprout inhibiting treatment and packaging methods on sprouting (%) of potatoes stored at room temperature is presented in Table 1. The data revealed that there was a progressive increase in sprouting with increasing storage period of tubers. There was no sprouting on 0 day, which significantly increased to 83.1% on 5th week of storage. Sprouting in potato tubers increases with increasing storage time, higher temperatures (above 15 °C), humidity and absence of chemical control (Hu *et al*., 2010; Wiltshire and Cobb, 1996) [5, 16]. Hot water dip (HWT) treated tubers resulted in significantly lower sprouting (26.0%) than untreated tubers (66.6%). In HWT, the heat is conducted from the tuber surface to the center and inactivates cell division. HWT is made more effective by water as heat transfer medium with high heat transfer rates. (Ranganna *et al*., 1998) [11]. Hu *et al*., 2010 [5] and Sheibani *et al*. (2012) [14] also reported better inhibition of sprouting in sweet potato by HWT.

Among various packaging methods, vacuum packaged tubers had significantly lower sprouting (40.0%) followed by net bag packaging (45.5%), while maximum spouting (53.4%) was observed in modified atmosphere packaging. The variation in sprouting among various packaging methods is due to non-availability of gases which are required during sprouting in vacuum packaging and high availability in MAP.

### Physiological loss in weight

The effect of sprout inhibiting treatment and packaging methods on physiological loss in weight (%) of potatoes stored at room temperature is presented in Table 2. The interactions between storage, sprout inhibiting treatment and packaging methods were found to be significant. There was progressive increase in physiological loss in weight (%) with increasing storage period of tubers. There was no physiological loss in weight on 0 day, which increased to 3.9% at 5th week of storage. The loss in weight with storage period is accompanied with sprouting and rapid respiration and utilization of reserved food material as observed by Edmunds *et al*. (2008) [1] and Mani *et al*. (2014) [8]. Hot water dip treated tubers resulted in significantly lower weight loss (1.4%) than untreated tubers (2.2%). The weight loss in tubers coincided with sprouting pattern as sprouting coincided with increased respiration. HWT have also been shown to inactivate the protein and tissue on the tuber surface which retards evaporation of water through skin leading to lower weight loss (Hu *et al*., 2010) [5].

Among various packaging methods, vacuum packaging resulted in significantly lower tuber weight loss (0.5%) followed by modified atmosphere packaging (0.7%), while maximum tuber weight loss was observed in net bag packaging (4.1%). This can be ascribed to lower moisture loss because of low permeability of polythene to water vapors and due to reduced respiratory rates of tubers due to creation of modified atmosphere.

### Firmness

The effect of sprout inhibiting treatment and packaging methods on firmness ($kg/cm^2$) of stored potatoes at room temperature is presented in Table 3. Firmness significantly decreased with increasing the storage period of tubers. The firmness was 13.0 $kg/cm^2$ at 0 day, which significantly decreased to 7.0 $kg/cm^2$ by 5th week of storage. This can be ascribed to loss of moisture from the tuber surface causing loss of turgidity and pectin breakdown ushering degradative changes in cell wall composition and structure (Wismer *et al*., 1998) [17]. Increased sprouting with storage resulted water loss by evapotranspiration and thus loss of firmness as reported by Rezaee *et al.* (2011) [12] and Hu *et al.* (2010) [5]. Hot water dip treated tubers retained significantly higher firmness (10.6 kg/cm$^2$) than untreated tubers (9.8 kg/cm$^2$). Since sprouting favors water loss by evapotranspiration (Rezaee *et al.*, 2011; Hu *et al.*, 2010) [12, 5], HWT treated tubers with less sprouting retained higher firmness at the end of storage.

Among various packaging methods, higher tuber firmness was observed in net bag packaging and modified atmosphere (10.3-10.7 kg/cm$^2$), both being at par with each other, while minimum tuber firmness was retained in vacuum packaging (9.6 kg/cm$^2$).

## Conclusion

There was a progressive increase in sprouting, PLW and decrease in firmness of potato tubers during storage at room temperature. HWT was an effective sprout inhibiting treatment and vacuum packaged potatoes had significantly lower sprouting. PLW among potatoes was lower in vacuum packaging, while maximum PLW was observed in net bag packaging. Thus, it can be inferred that HWT is a low cost method that can be employed by farmers to store potatoes for longer shelf life at room temperature.


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**Table 1:** Effect of sprout inhibiting treatment and packaging methods on sprouting (%) of stored potatoes at room temperature

| Period of Storage (weeks) | Treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Control | | | | Hot Water Dip | | | | Overall mean |
| | Net Bag | Modified Atmosphere | Vacuum | Mean | Net Bag | Modified Atmosphere | Vacuum | Mean | |
| 0 | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) |
| 1 | 54.3 (47.6) | 72.6 (58.6) | 31.1 (34.0) | 52.7 (46.7) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 26.3 (24.8) |
| 2 | 64.9 (54.0) | 81.2 (66.7) | 48.8 (44.4) | 65.0 (55.1) | 18.7 (25.8) | 21.0 (27.4) | 13.9 (22.1) | 17.9 (25.1) | 41.4 (40.1) |
| 3 | 78.1 (65.3) | 100.0 (87.1) | 67.6 (56.1) | 81.9 (69.5) | 25.7 (30.5) | 28.6 (32.3) | 19.9 (26.5) | 24.7 (29.8) | 53.3 (49.6) |
| 4 | 100.0 (87.1) | 100.0 (87.1) | 100.0 (87.1) | 100.0 (87.1) | 43.0 (41.0) | 59.5 (50.8) | 39.3 (38.8) | 47.3 (43.6) | 73.6 (65.3) |
| 5 | 100.0 (87.1) | 100.0 (87.1) | 100.0 (87.1) | 100.0 (87.1) | 61.0 (51.8) | 78.3 (65.7) | 59.5 (50.8) | 66.3 (56.1) | 83.1 (71.6) |
| Mean | | | | 66.6 (58.1) | | | | 26.0 (26.7) | |

| Period of Storage (weeks) | Packaging methods | | | Overall mean |
|---|---|---|---|---|
| | Net Bag | Modified Atmosphere | Vacuum | |
| 0 | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) |
| 1 | 27.2 (25.2) | 36.3 (30.7) | 15.5 (18.4) | 26.3 (24.8) |
| 2 | 41.8 (39.9) | 51.1 (47.1) | 31.4 (33.3) | 41.4 (40.1) |
| 3 | 51.9 (47.9) | 64.3 (59.7) | 43.8 (41.3) | 53.3 (49.6) |
| 4 | 71.5 (64.1) | 79.7 (69.0) | 69.6 (62.9) | 73.6 (65.3) |
| 5 | 80.5 (69.4) | 89.2 (76.4) | 79.7 (68.9) | 83.1 (71.6) |
| Mean | 45.5 (41.6) | 53.4 (47.6) | 40.0 (37.9) | |

CD at 5% Storage (S) = 4.28 Treatment (T) = 2.47 Packaging methods (P) = 3.02 SxT = 6.05 SxP= NS TxP = NS SxTxP = 10.48 Values in the parenthesis are transformed values; NS – non significant

**Table 2:** Effect of sprout inhibiting treatment and packaging methods on physiological loss in weight (PLW) (%) of stored potatoes at room temperature

| Period of Storage (weeks) | Treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Control | | | | Hot Water Dip | | | | Overall mean |
| | Net Bag | Modified Atmosphere | Vacuum | Mean | Net Bag | Modified Atmosphere | Vacuum | Mean | |
| 0 | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) |
| 1 | 3.3 (10.9) | 0.5 (4.8) | 0.4 (4.6) | 1.4 (6.8) | 0.9 (6.2) | 0.4 (4.5) | 0.0 (2.9) | 0.4 (4.5) | 0.9 (5.7) |
| 2 | 4.8 (12.9) | 0.7 (5.6) | 0.6 (5.3) | 2.0 (7.9) | 2.8 (10.1) | 0.5 (4.9) | 0.3 (4.3) | 1.2 (6.4) | 1.6 (7.2) |
| 3 | 5.6 (13.9) | 0.9 (6.0) | 0.7 (5.6) | 2.4 (8.5) | 3.3 (10.9) | 0.7 (5.5) | 0.4 (4.7) | 1.5 (7.0) | 1.9 (7.8) |
| 4 | 7.0 (15.6) | 1.0 (6.4) | 0.9 (6.2) | 3.0 (9.5) | 4.3 (12.4) | 0.8 (5.9) | 0.8 (5.8) | 2.0 (8.1) | 2.5 (8.7) |
| 5 | 10.5 (19.1) | 2.1 (8.7) | 1.4 (7.3) | 4.6 (11.7) | 7.0 (15.6) | 1.3 (7.0) | 1.0 (6.4) | 3.1 (9.7) | 3.9 (10.7) |
| Mean | | | | 2.2 (7.9) | | | | 1.4 (6.4) | |

| Period of Storage (weeks) | Packaging methods | | | Overall mean |
|---|---|---|---|---|
| | Net Bag | Modified Atmosphere | Vacuum | |
| 0 | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) | 0.0 (2.9) |
| 1 | 2.1 (8.6) | 0.4 (4.7) | 0.2 (3.8) | 0.9 (5.7) |
| 2 | 3.8 (11.5) | 0.6 (5.3) | 0.5 (4.8) | 1.6 (7.2) |
| 3 | 4.5 (12.4) | 0.8 (5.8) | 0.6 (5.1) | 1.9 (7.8) |
| 4 | 5.7 (14.0) | 0.9 (6.2) | 0.9 (6.0) | 2.5 (8.7) |
| 5 | 8.7 (17.4) | 1.7 (7.9) | 1.2 (6.9) | 3.9 (10.7) |
| Mean | 4.1 (11.1) | 0.7 (5.4) | 0.5 (4.9) | |

CD at 5% Storage (S) = 0.37 Treatment (T) = 0.21 Packaging methods (P) = 0.26 SxT = 0.51 SxP= 0.63 TxP = 0.37 SxTxP = 0.89 Values in The parenthesis are transformed values; NS – non significant

**Table 3:** Effect of sprout inhibiting treatment and packaging methods on firmness (kg/cm$^2$) of stored potatoes at room temperature

| Period of Storage (weeks) | Treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Control | | | | Hot Water Dip | | | | |
| | Net Bag | Modified Atmosphere | Vacuum | Mean | Net Bag | Modified Atmosphere | Vacuum | Mean | Overall mean |
| 0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 |
| 1 | 11.8 | 11.5 | 11.4 | 11.6 | 12.6 | 12.1 | 11.7 | 12.1 | 11.9 |
| 2 | 11.3 | 10.9 | 10.1 | 10.8 | 11.9 | 11.6 | 10.4 | 11.3 | 11.0 |
| 3 | 10.1 | 9.5 | 9.0 | 9.5 | 10.8 | 10.4 | 9.8 | 10.3 | 9.9 |
| 4 | 9.2 | 7.9 | 6.1 | 7.7 | 9.6 | 9.1 | 8.4 | 9.0 | 8.4 |
| 5 | 7.5 | 6.4 | 5.5 | 6.5 | 8.0 | 7.6 | 7.1 | 7.6 | 7.0 |
| Mean | | | | 9.8 | | | | 10.6 | |

| Period of Storage (weeks) | Packaging methods | | | Overall mean |
|---|---|---|---|---|
| | Net Bag | Modified Atmosphere | Vacuum | |
| 0 | 13.0 | 13.0 | 13.0 | 13.0 |
| 1 | 12.2 | 11.8 | 11.6 | 11.9 |
| 2 | 11.6 | 11.3 | 10.3 | 11.0 |
| 3 | 10.5 | 10.0 | 9.4 | 9.9 |
| 4 | 9.4 | 8.5 | 7.3 | 8.4 |
| 5 | 7.8 | 7.0 | 6.3 | 7.0 |
| Mean | 10.7 | 10.3 | 9.6 | |

CD at 5% Storage (S) = 0.46 Treatment (T) = 0.26 Packaging methods (P) = 0.32 SxT = NS SxP= NS TxP = NS SxTxP = NS Values in the parenthesis are transformed values; NS – non significant

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