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EFFECT OF POSTHARVEST OZONE FUMIGATION ON POTATO TUBERS DURING STORAGE

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ABSTRACT

Potatoes, as a widely cultivated and essential tuber crop, are highly susceptible to substantial post-harvest losses, with as much as 30% of the yield becoming waste primarily due to the crop's semi-perishable nature. Once harvested, the tubers continue metabolic respiration, which can lead to significant reductions in both weight and overall quality, ultimately diminishing their market value. Key factors contributing to these post-harvest losses include moisture depletion, microbial contamination and tuber sprouting all of which compromise the commercial appeal and longevity of stored potatoes.

Ozone, an environmentally friendly "green technology," has emerged as a promising solution due to its strong oxidative properties, which provide effective antimicrobial action while preserving tuber quality during storage. In a comprehensive study aimed at assessing the effects of ozone treatment on the post-harvest quality of potatoes, tubers packed in polypropylene (PP) leno mesh bags were exposed to varying ozone gas concentrations. Key parameters, including physiological loss in weight (PLW), rate of sprouting, degree of rotting, proportion of healthy tubers, moisture retention and tuber firmness, were meticulously analysed to determine the optimal ozone concentration for maximum preservation. Among the concentrations tested, a 5455.8 μL L^{-1} (T_3) ozone treatment in both ambient and cold storage conditions demonstrated the most substantial benefits by effectively reducing PLW (6.30% and 4.69%), suppressing sprouting (7.91% and 1.27%), rotting (9.39% and 0.67%) and maintaining the healthy tubers (76.05% and 93.00%), moisture content (90.01% and 90.07%), firmness (110.70% and 105.38%) and overall health of the tubers over the storage period.
***Keywords*: Potato, Ozone fumigation, Rotting, Storage, Quality.**

Introduction

The potato (*Solanum tuberosum* L.), a key crop in the Solanaceae family, is the most widely cultivated tuber and has a history of human consumption spanning almost 8,000 years. Native to South America, its global distribution was significantly influenced by European countries like Portugal and Britain. Today, the potato ranks as the fourth most essential food crop worldwide after rice, wheat, and maize and is the top-ranking non-cereal crop. Beyond being a staple food, potatoes are processed into a variety of food items and utilized in industries to produce starch and alcoholic beverages (Reddy *et al.*, 2018).

Global potato production now surpasses 300 million metric tons annually. According to FAO data, in 2021, global production reached 376 million metric tons across 18.1 million hectares, with Asia accounting for 52% of this total. India, the second-largest producer, harvested 54.2 million metric tons from 2.2 million hectares (Jaiswal *et al.*, 2024).

Potatoes, as a major tuber crop, are highly perishable and subject to substantial post-harvest losses, with up to 30% of the yield going to waste. After harvest, tubers continue to respire, leading to weight and quality deterioration. Key factors in these losses include moisture depletion, microbial infections, and sprouting, all of which reduce the crop's commercial appeal. Sprouting potatoes lose dry matter and turgor pressure while increasing sugar content, which diminishes their desirability. Limited storage options and alternative markets often lead to surpluses at peak harvest times, causing price drops, while scarcity after 2–3 months drives prices back up. Many farmers, lacking adequate storage facilities, are compelled to sell at low prices, underscoring the need for effective post-harvest strategies to extend shelf life and preserve quality (El-Ramady *et al.,* 2015).

Ozone, a powerful oxidizing agent, is emerging as an effective method to extend the shelf life of fruits and vegetables. Chemically represented as O_3, ozone is a pale blue gas with a pungent odour when derived from dry air or colourless when sourced from pure oxygen. It is a dark blue liquid at -112°C and a gas at room temperature, making it safe for use in the agro-food industry, as authorized by the European Food Safety Authority and the FDA (Cisterna *et al*., 2018).

Ozone inactivates microorganisms through a complex process that involves oxidizing essential cellular components. Studies have shown that ozone attacks the cell surface of microbes, causing leakage of cellular contents and eventually microbial lysis. It also oxidizes internal cellular proteins, leading to rapid cell death (Feliziani *et al*., 2014). The use of ozone for post-harvest fumigation of potatoes is still limited, but there is growing interest in exploring its antimicrobial properties and its potential impact on potato physiology, storage, and disease prevention.

Material and Methods

Potato

Freshly harvested potatoes (*Solanum tuberosum* L.), specifically the Kufri Jyoti variety, were selected for this study. These tubers were procured from AICRP (Potato) from UAS Dharwad during October 2023. Damaged or diseased tubers were removed. The selected potatoes were then meticulously cleaned under running tap water to eliminate dirt and soil residues and subsequently wiped with dry cloth. Each tuber weighed approximately 70-100 grams.

Ozonation system

The Ozonation System is an electrically operated device that produces ozone. It uses oxygen (O_2) as feed gas and the corona discharge method to convert it to ozone (O_3). We used SEONICS ozone generator for ozone generation with mainly two parts.

I. Oxygen Concentrator

It concentrates high purity oxygen from ambient air by purging the nitrogen from the air, as air contains 21 per cent oxygen and 78 per cent nitrogen. Oxygen concentration systems separate oxygen from compressed air through a process known as pressure swing adsorption. This process employs molecular sieves, which adsorb nitrogen from the air at high pressure and release the nitrogen at low pressure.

II Ozone generator

When purified oxygen enters the ozone generator, the corona discharge method splits the normal oxygen molecules into single atoms. These atoms then attach to other O_2 molecules in the air to form ozone in grams per cubic meter. Then, it needs to be converted to micro litre per litre. Therefore, purified oxygen passes through the oxygen concentrator to the ozone generator litre per minute which range from 0.5 to 5 litre per minute, which here one litre concentrated oxygen is used to produce 52g ozone per meter cubic (1 g/m^3 = mg/litre) 1g/m^3 = 467 ppm of ozone in air; 52 mg/litre = 24284ppm;1 ppm = 2.14 mg/m^3 in air (by volume) or 1ppm = 0.00214mg/litre which 24284ppm = 52mg/litre.

Therefore, when 1 litre per minute concentrated oxygen is passed to ozone generator 51.96 mg/litre/minute ozone is produced. Here, I used 9 litres three LDPE airtight boxes (connected to ozone generator by 6mm Outer Dia tube connector) for all the treatment, in each box 2 litre volume of box space was occupied by potatoes, 7 litre spaces was available for ozone. To get total concentration of ozone of the study, 7 litre volume of each box was multiplied with 51.96 mg/litre/minute and different period of time *i.e.* 10, 15 and 20min leading to a final concentration of ozone are 3637.2, 5455.8 and 7274.4 µl L^{-1} respectively.

Treatment details

T_1- Control

T_2-Ozone 3637.2 µl L^{-1} ozone

T_3-Ozone 5455.8 µl L^{-1} ozone

T_4-Ozone 7274.4 µl L^{-1} ozone

T_5-Ozone 9093.0 µl L^{-1} ozone

T_6-Ozone 10911.6 µl L^{-1} ozone

Methodology

Potato tubers were collected from AICRP (Potato) from UAS Dharwad and underwent a meticulous treatment process. Initially, the potatoes were washed with tap water to remove dirt and soil, followed by the careful removal of diseased, defective and green tubers, ensuring only healthy potatoes remained. These selected tubers were wiped with dry cloth to eliminate surface moisture, a crucial step in preventing potential rotting during storage. Subsequently, the dried potatoes were treated with ozone in LDPE boxes sealed tightly to varying concentrations. Post-treatment, the potatoes were exposed to ambient air by partially opening the box lids to allow any residual ozone to dissipate, mitigating potential risks during subsequent handling.

The treated potatoes were packed in PP leno mesh bags then divided into two storage conditions: ambient storage with observations every 15 days over a span of 75 days and cold storage (maintained between 5°C and 10°C) with observations every 30 days over a span of 150 days. These observations aimed to evaluate the efficacy of ozone treatment in maintaining potato quality, assessing factors such as sprouting, decay and overall shelf life under different storage conditions.

Observations recorded

Physiological loss in weight (%)

In each replication, 50 tubers were set aside for recording the PLW. The marked tubers in each replication of the pertinent treatment were individually weighed to record the beginning weight before storage. Following that, the tubers were weighed at regular interval (15 and 30 days after storage). The cumulative weight losses of tubers were calculated using the formula below and expressed as a percentage of physiological weight loss.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight(g)} - \text{Final weight(g)}}{\text{Initial weight (g)}} \text{ x } 100$$

Sprouting percentage

The sprouted tubers were isolated from the lot and weighed on an automated balance to determine the sprouting percentage on the designated days after storage. The formula below was used to calculate the sprouting percentage, which represented the weight of the tubers that had sprouted during storage period.

$$\text{Sprouting (\%)} = \frac{\text{Weight of the sprouted tubers (g)}}{\text{Initial weight of tubers (g)}} \times 100$$

Rotting percentage

The percentage of rotting was calculated by removing the rotten tubers from the batch and weighing them on an electronic balance. The following formula was used to calculate the rotting percentage, which represented the weight of the tubers that were rotten during storage period.

$$\text{Rotting (\%)} = \frac{\text{Weight of the rotted tubers (g)}}{\text{Initial weight of tubers (g)}} \times 100$$

Healthy tubers (%)

The weight of healthy tubers was measured after the separation of the rotted and sprouted tubers at the conclusion of every storage interval. Utilizing the following formula, the recovery of healthy tubers was determined.

$$\text{Healthy tubers (\%)} = \frac{\text{Wight of the healthy tubers obtained (g)}}{\text{Initial weight of the tubers (g)}} \times 100$$

Moisture content (%)

The moisture content of known quantity of potato tuber was determined using a Radwag moisture analyser (Model: MAC 50, Make Poland) and expressed in per cent. The moisture analyser indicated the end point of measurement by a beep sound giving constant value for moisture.

Tuber firmness (N)

Tuber firmness was captured using TA-XT-Plus texture analyser (Stable Micro Systems, London, England). Using shearing probe (blade set) at two equatorial sites a 10 mm plunger tip was used to express the tuber firmness. A record was made of the amount of force needed to shear the tuber. In Newton (N) units, readings were expressed. Prior to the experiment's conclusion, data were originally recorded and then during storage periods.

Statistical analysis

Web Agri Stat Package (WASP) version 2.0 was used for the statistical analysis (Jangam and Thali, 2010). ANOVA was used to evaluate all of the acquired data in one method. Post-doc testing employing the Duncan multiple range test identified significant differences between averages at p=0.05.

Result and Discussion

Physiological loss in weight (PLW %)

Table 1 shows data on the physiological weight loss (PLW) percentage of potato tubers stored under both ambient and cold conditions. The results indicate significant differences among treatments over the storage period, with a general trend of increasing PLW as storage duration extended. In ambient conditions, PLW increase from 2.22% on the 15^{th} day to 14.79% by the 75^{th} day. Among treatments, T_3 had the lowest PLW at 75 days (12.60%), closely followed by T_2 at 12.92%, while the highest PLW was observed in the control (T_1) at 17.52%, similar to T_5. Under cold storage, significant differences were also observed across treatments over a period of up to 150 days. PLW gradually increased, beginning at 1.59% on day 30 and reaching 11.45% by day 150. By the end of this period, the lowest PLW was recorded in T_3 at 9.01%, closely followed by T_2 at 9.81%, while the highest PLW was in the control (T_1) at 14.12%. The increased PLW in tubers treated with higher ozone concentrations may be due to enhanced dehydration, which could damage the epidermis and cuticle tissues of the tubers (Palou *et al.*, 2002). These findings are consistent with those of Minas *et al.* (2010), Nadas *et al.* (2003), Rodoni *et al.* (2010) and Rahimi *et al.* (2020). The maximum PLW observed in the untreated tubers (T_1) is likely due to uncontrolled metabolic processes, such as respiration and transpiration.

Sprouting (%)

Table 2 presents the trends in potato tuber sprouting under both ambient and cold storage conditions. Across all treatments, sprouting percentages consistently increased as storage time progressed. Sprouting steadily increased throughout the storage period, with the average sprouting rate rising from 0.00% at the start to 30.79% by the 75th day. After 75 days, treatment T_3 had the lowest sprouting rate at 21.24%, significantly lower than other treatments. T_2 followed with a sprouting rate of 26.30%. The highest sprouting occurred in the control T_1 at 35.51%. In cold storage, the data revealed a significant difference in the sprouting percentage of potato tubers among treatments, except for the first 60 days when no sprouting occurred. Sprouting began after 60 days, increasing steadily across all treatments, with the mean sprouting rate rising from 0.00% initially to 7.18% by the 150th day of storage. At 150 days, the lowest sprouting was recorded in treatment T_3 at 3.53%, which was similar to T_2 at 4.67%. The highest sprouting was observed in the control T_1 at 9.75%. It may be attributed to due to strong oxidizing effect provided by ozone that can induce oxidative stress in potato tubers. This stress can alter the metabolic pathways associated with sprouting, effectively delaying or inhibiting the growth of sprouts. Similar kind of results was observed by (Rekha *et al.*, 2014) in onion.

Rotting (%)

Table 3 presents data on the effects of postharvest ozone fumigation on the rotting of potato tubers under both ambient and cold storage conditions. Across all treatments, tuber spoilage due to rotting increased as the storage duration extended. This is reflected in the mean rotting percentage, which ranged from 0.00% to 18.78% after 75 days of ambient storage. There were significant differences among treatments, except during the initial 15 days of storage. By the 75th day of ambient storage, treatment T_3 showed the lowest rotting rate at 14.25%, followed by T_2 at 15.67% and highest rotting was recorded in the control T_1 at 25.92%. Cold storage data showed significant differences in potato tuber treatments over time, except for the first 90 days, during which no rotting occurred. Rotting progressively increased in all treatments, with the mean rate rising from 0.00% at day 90 to 4.69% by day 150 of storage. At 150 days, the lowest rotting rate was observed in treatment T_3 at 2.12%, closely followed by T_2 at 2.50%. The highest rotting was recorded in the control T_1, at 9.75%. This phenomenon can be attributed to ozone's remarkable capability to permeate protective layers, rendering spores nonviable and consequently, hindering the infection potential of plant pathogens (Chauhan *et al.*, 2011). Ozone induces oxidative stress in microbial cells, leading to cell damage and death. This oxidative environment disrupts the normal functioning of pathogens, thereby preventing them from causing rot in the potatoes. Similar results were found in (Hutla *et al.*, 2020)

Healthy tubers

Table 4 shows the significant differences in the percentage of healthy potato tubers after postharvest ozone fumigation under both ambient and cold storage conditions. In all treatments, the percentage of healthy tubers decreased over time, ranging from 97.76% at 15 days to 35.64% after 75 days of ambient storage. At 75 days of ambient storage, treatment T_3 had the highest percentage of healthy tubers at 51.91%, followed by T_2 at 45.11% and lowest percentage of healthy tubers was observed in the control T_1 at 21.05%, followed by T_5 at 29.11%. In cold storage, significant differences between treatments appeared after 60 days, with healthy tuber percentages decreasing from 98.41% at the start to 76.38% by day 150. At 150 days, the highest percentage of healthy tubers was recorded in T_3 at 83.61%, followed by T_2 at 83.02% and lowest was in the control T_1 at 66.38%, followed by T_6 at 72.59%. This may be attributed to minimum physiological loss in weight (%), per cent rotting and per cent sprouting in these treatments. These results are in conformity with the findings of (Bansal *et al.*, 2015).

Moisture content (%)

Table 5 highlights the effects of postharvest ozone fumigation on the moisture content of potato tubers under both ambient and cold storage conditions. Across all treatments, moisture content consistently decreased as the storage period lengthened. For example, the average moisture content declined from

90.75% to 83.21% over 75 days of ambient storage. After 75 days, treatment T_2 retained the highest moisture content at 85.94%, which was similar to T_3 at 85.65% and lowest moisture retention was recorded in the control T_1, with 78.60%. In cold storage, significant differences between treatments emerged, with moisture content decreasing from 90.72% at the start to 82.75% by the 150th day. At 150 days, the highest moisture retention was observed in T_3 at 86.01%, followed by T_2 at 85.32% and lowest was in the control T_1 at 78.12%. Ozone helps to maintain moisture levels in stored potatoes by reducing microbial activity that can lead to dehydration. Study found ozone treated tubers had 0.86% less water loss, compared to untreated control (Hutla *et al.*, 2020).

Tuber firmness (N)

In general, firmness of potato tubers was found to decrease as the storage duration progressed in all the treatments during both ambient and cold storage data depicted in Table 6. For instance, the average firmness ranged from 112.97 N to 99.11 N after 75 days of ambient storage. At 75 days of storage T_3 exhibited (105.86 N) maximum firmness was followed by treatment T_6 (101.36 N) and lower firmness was registered in treatment T_1 control (90.82 N). In cold storage, the data revealed a significant decline in the mean storage values between treatments, dropping from 112.53 N on the initial day to 90.35 N on the 150th day. With further progress in storage at 150th day of cold storage, significantly higher firmness was registered in the treatment T_3 (94.05 N) followed by T_2 (93.80 N) and Lower firmness was registered in T_1 (Control) (83.16 N). (Rodoni *et al.*, 2010) conducted analyses of the cell wall and found a decreased activity of pectin methylesterase (PME) in ozone-exposed tomato fruit. This suggested that delayed fruit softening might be due to reduced solubilisation and depolymerisation of pectin polysaccharides. There is clear evidence in literature that ozone may affect both ripening and enzymes, e.g. through signalling molecules

Table 1 : Effect of postharvest ozone fumigation on physiological loss in weight (%) of potato tubers under ambient and cold storage

Treatment	Ambient storage (29±1°C, RH 43±1%)					Mean	Cold storage (8±2°C, RH 85-95%)					Mean
	Days after storage						Days after storage					
	15	30	45	60	75		30	60	90	120	150	
T_1	2.04^d	3.47^d	8.65^a	12.19^a	17.52^a	**8.77**	2.41^a	4.37^a	7.10^a	10.20^a	14.12^a	**7.64**
T_2	2.16^c	3.46^d	5.64^d	8.50^d	12.92^d	**6.87**	1.13^d	3.13^b	4.80^d	6.47^d	9.81^c	**5.06**
T_3	2.14^c	3.51^d	7.35^e	7.61^e	12.60^d	**6.30**	1.06^d	2.47^c	4.59^d	6.36^d	9.01^c	**4.69**
T_4	2.24^b	3.66^c	7.32^d	9.02^c	13.68^c	**7.18**	1.37^c	3.51^b	5.66^c	8.23^c	9.94^c	**5.74**
T_5	2.26^b	4.07^a	8.04^b	12.18^a	17.21^a	**8.75**	1.53^c	3.95^a	5.77^c	9.20^{bc}	12.42^b	**6.57**
T_6	2.45^a	3.82^b	7.74^c	11.31^b	14.80^b	**8.02**	2.04^b	4.01^a	6.37^b	9.52^{ab}	13.45^{ab}	**7.07**
Mean	**2.22**	**3.66**	**7.46**	**10.13**	**14.79**	**7.65**	**1.59**	**3.57**	**5.71**	**8.33**	**11.45**	**6.13**
S.Em±	0.01	0.02	0.01	0.03	0.15	0.04	0.06	0.14	0.23	0.34	0.45	0.24
CD at 1%	0.05	0.09	0.05	0.13	0.62	0.18	0.25	0.59	0.94	1.39	1.87	1.00

Note: Similar alphabets within the column represent non-significant differences
T_1. Control — T_2. Ozone 3637.2 µl L^{-1} — T_3. Ozone 5455.8 µl L^{-1}
T_4. Ozone 7274.4 µl L^{-1} — T_5. Ozone 9093.0 µl L^{-1} — T_6. Ozone 10911.6µl L^{-1}

Table 2 : Effect of postharvest ozone fumigation on sprouting (%) of potato tubers under ambient and cold storage

Treatment	Ambient storage (29±1°C, RH 43±1%)					Mean	Cold storage (8±2°C, RH 85-95%)					Mean
	Days after storage						Days after storage					
	15	30	45	60	75		30	60	90	120	150	
T_1	0.00^a	8.69^a	15.24^a	23.18^a	35.51^a	**16.52**	0.00^a	0.00^a	3.90^a	6.83^a	9.75^a	**4.09**
T_2	0.00^a	3.15^d	7.20^d	15.21^d	26.30^c	**10.37**	0.00^a	0.00^a	1.67^b	2.33^d	4.67^d	**1.73**
T_3	0.00^a	2.63^e	5.33^f	10.38^e	21.24^d	**7.91**	0.00^a	0.00^a	1.06^c	1.76^d	3.53^d	**1.27**
T_4	0.00^a	4.36^c	9.32^c	20.74^b	35.28^a	**13.94**	0.00^a	0.00^a	3.99^a	5.57^b	9.00^b	**3.71**
T_5	0.00^a	3.19^d	6.81^e	19.10^c	31.80^b	**12.18**	0.00^a	0.00^a	3.63^a	4.84^c	8.07^b	**3.30**
T_6	0.00^a	6.69^b	13.33^b	22.26^a	34.59^a	**15.37**	0.00^a	0.00^a	3.73^a	5.90^b	8.06^b	**3.53**
Mean	**0.00**	**4.78**	**9.54**	**18.48**	**30.79**	**12.71**	**0.00**	**0.00**	**2.99**	**4.53**	**7.18**	**2.94**
S.Em±	0.00	0.01	0.02	0.39	0.54	0.19	0.00	0.00	0.13	0.20	0.31	0.12
CD at 1%	NS	0.06	0.11	1.60	2.21	0.79	NS	NS	0.55	0.81	1.27	0.52

Note: Similar alphabets within the column represent non-significant differences — NS- Non Significant
T_1. Control — T_2. Ozone 3637.2 µl L^{-1} — T_3. Ozone 5455.8 µl L^{-1}
T_4. Ozone 7274.4 µl L^{-1} — T_5. Ozone 9093.0 µl L^{-1} — T_6. Ozone 10911.6µl L^{-1}

Table 3 : Effect of postharvest ozone fumigation on rotting (%) of potato tubers under ambient and cold storage

Treatment	Ambient storage (29±1°C, RH 43±1%)					Mean	Cold storage (8±2°C, RH 85-95%)					Mean
	Days after storage						Days after storage					
	15	30	45	60	75		30	60	90	120	150	
T_1	0.00^{a}	10.75^{a}	15.31^{b}	21.59^{a}	25.92^{a}	**14.71**	0.00^{a}	0.00^{a}	0.00^{a}	3.90^{a}	9.75^{a}	**2.73**
T_2	0.00^{a}	8.77^{d}	12.70^{e}	14.52^{d}	15.67^{d}	**10.33**	0.00^{a}	0.00^{a}	0.00^{a}	2.20^{d}	2.50^{d}	**0.94**
T_3	0.00^{a}	7.65^{f}	11.88^{f}	13.21^{e}	14.25^{e}	**9.39**	0.00^{a}	0.00^{a}	0.00^{a}	1.27^{e}	2.12^{d}	**0.67**
T_4	0.00^{a}	8.93^{b}	13.84^{d}	16.34^{c}	17.58^{c}	**11.33**	0.00^{a}	0.00^{a}	0.00^{a}	3.00^{c}	3.85^{c}	**1.37**
T_5	0.00^{a}	7.75^{e}	19.44^{a}	20.93^{b}	21.88^{b}	**14.00**	0.00^{a}	0.00^{a}	0.00^{a}	2.90^{c}	4.03^{c}	**1.38**
T_6	0.00^{a}	8.86^{c}	14.16^{c}	16.47^{c}	17.39^{c}	**11.37**	0.00^{a}	0.00^{a}	0.00^{a}	3.54^{b}	5.90^{b}	**1.88**
Mean	**0.00**	**8.78**	**14.56**	**17.18**	**18.78**	**11.86**	**0.00**	**0.00**	**0.00**	**2.80**	**4.69**	**1.49**
S.Em±	0.00	0.02	0.02	0.09	0.11	0.04	0.00	0.00	0.00	0.11	0.18	0.05
CD at 1%	NS	0.10	0.10	0.40	0.45	0.21	NS	NS	NS	0.47	0.75	0.24

Note: Similar alphabets within the column represent non-significant differences NS- Non Significant
T_1. Control T_2. Ozone 3637.2 µl L^{-1} T_3. Ozone 5455.8 µl L^{-1}
T_4. Ozone 7274.4 µl L^{-1} T_5. Ozone 9093.0 µl L^{-1} T_6. Ozone 10911.6µl L^{-1}

Table 4 : Effect of postharvest ozone fumigation on healthy tubers (%) of potato tubers under ambient and cold storage

Treatment	Ambient storage (29±1°C, RH 43±1%)					Mean	Cold storage (8±2°C, RH 85-95%)					Mean
	Days after storage						Days after storage					
	15	30	45	60	75		30	60	90	120	150	
T_1	97.86^{a}	77.09^{f}	60.80^{f}	43.04^{f}	21.05^{e}	**59.96**	97.59^{f}	95.63^{f}	89.00^{f}	79.07^{f}	66.38^{f}	**85.53**
T_2	97.84^{b}	84.62^{b}	74.46^{b}	61.77^{b}	45.11^{b}	**72.76**	98.87^{b}	96.87^{b}	93.53^{b}	89.00^{b}	83.02^{b}	**92.25**
T_3	97.86^{a}	86.21^{a}	75.47^{a}	68.80^{a}	51.91^{a}	**76.05**	98.94^{a}	97.53^{a}	94.35^{a}	90.61^{a}	83.61^{a}	**93.00**
T_4	97.76^{c}	83.05^{d}	69.52^{c}	53.90^{c}	33.46^{c}	**67.53**	98.63^{c}	96.49^{c}	90.35^{d}	83.20^{c}	77.24^{c}	**89.18**
T_5	97.74^{d}	84.99^{c}	65.72^{d}	47.79^{e}	29.11^{d}	**65.07**	98.47^{d}	96.05^{d}	90.60^{c}	83.06^{d}	75.48^{d}	**88.73**
T_6	97.55^{e}	80.61^{e}	64.77^{e}	49.96^{d}	33.22^{c}	**65.22**	97.96^{e}	95.99^{e}	89.90^{e}	81.06^{e}	72.59^{e}	**87.50**
Mean	**97.76**	**82.76**	**68.45**	**54.21**	**35.64**	**67.76**	**98.41**	**96.42**	**91.28**	**84.33**	**76.38**	**89.36**
S.Em±	0.17	0.36	0.29	0.31	0.45	0.32	0.36	0.22	0.40	0.42	0.36	0.28
CD at 1%	0.71	1.48	1.19	1.27	1.83	1.32	1.49	0.93	1.63	1.72	1.49	1.16

Note: Similar alphabets within the column represent non-significant differences NS- Non Significant
T_1. Control T_2. Ozone 3637.2 µl L^{-1} T_3. Ozone 5455.8 µl L^{-1}
T_4. Ozone 7274.4 µl L^{-1} T_5. Ozone 9093.0 µl L^{-1} T_6. Ozone 10911.6µl L^{-1}

Table 5 : Effect of postharvest ozone fumigation on moisture (%) of potato tubers under ambient and cold storage

Treatment	Ambient storage (29±1°C, RH 43±1%)					Mean	Cold storage (8±2°C, RH 85-95%)					Mean
	Days after storage						Days after storage					
	15	30	45	60	75		30	60	90	120	150	
T_1	88.34^{f}	87.92^{e}	84.89^{f}	81.46^{f}	78.60^{c}	**84.24**	88.72^{c}	87.30^{c}	83.30^{d}	81.50^{e}	78.12^{f}	**83.78**
T_2	92.62^{b}	91.28^{b}	89.45^{b}	87.55^{b}	85.94^{a}	**89.36**	92.92^{b}	90.85^{b}	89.95^{a}	87.01^{b}	85.32^{b}	**89.21**
T_3	92.68^{a}	92.50^{a}	90.64^{a}	88.59^{a}	85.65^{a}	**90.01**	93.10^{a}	91.66^{a}	91.07^{a}	88.54^{a}	86.01^{a}	**90.07**
T_4	91.83^{c}	90.45^{c}	88.38^{c}	85.46^{c}	83.70^{b}	**87.96**	91.37^{b}	90.50^{c}	87.95^{b}	86.00^{b}	84.03^{c}	**87.97**
T_5	89.32^{e}	87.84^{e}	85.26^{e}	84.26^{e}	82.95^{b}	**85.92**	88.74^{c}	87.86^{d}	86.52^{c}	84.45^{c}	82.09^{d}	**85.93**
T_6	89.74^{d}	88.48^{d}	86.78^{d}	84.16^{d}	82.41^{b}	**86.31**	89.51^{c}	88.10^{d}	86.88^{bc}	83.16^{d}	80.91^{e}	**85.71**
Mean	**90.75**	**89.74**	**87.56**	**85.25**	**83.21**	**87.30**	**90.72**	**89.38**	**87.61**	**85.11**	**82.75**	**87.11**
S.Em±	0.07	0.03	0.01	0.01	0.02	0.02	0.48	0.49	0.41	0.39	0.38	0.43
CD at 1%	0.29	0.13	0.07	0.06	0.09	0.12	1.98	2.00	1.68	1.60	1.58	1.76

Note: Similar alphabets within the column represent non-significant differences NS- Non Significant
T_1. Control T_2. Ozone 3637.2 µl L^{-1} T_3. Ozone 5455.8 µl L^{-1}
T_4. Ozone 7274.4 µl L^{-1} T_5. Ozone 9093.0 µl L^{-1} T_6. Ozone 10911.6µl L^{-1}

Table 6 : Effect of postharvest ozone fumigation on tuber firmness (N) of potato tubers under ambient and cold storage

Treatment	Ambient storage (29±1°C, RH 43±1%)					Mean	Cold storage (8±2°C, RH 85-95%)					Mean
	Days after storage						Days after storage					
	15	30	45	60	75		30	60	90	120	150	
T_1	110.60^f	108.44^e	100.35^f	95.51^f	90.82^f	**101.14**	110.43^b	105.08^c	97.06^d	90.28^e	83.16^e	**97.20**
T_2	113.29^c	110.94^c	105.60^d	102.41^d	98.97^d	**106.24**	113.49^a	110.84^{ab}	104.09^{ab}	99.47^{ab}	93.80^{ab}	**104.33**
T_3	115.29^a	113.46^a	110.35^a	108.56^a	105.86^a	**110.70**	114.94^a	112.23^a	105.24^a	100.45^a	94.05^a	**105.38**
T_4	114.51^b	111.36^b	106.32^c	103.93^c	100.28^c	**107.28**	114.00^a	111.95^a	104.56^a	98.62^{bc}	92.72^b	**104.37**
T_5	112.28^d	110.45^d	104.64^e	101.29^e	97.36^e	**105.20**	111.30^b	109.44^b	101.83^{bc}	97.64^c	90.48^c	**102.13**
T_6	111.85^e	110.17^f	109.41^b	106.91^b	101.36^b	**105.94**	111.01^b	105.72^c	101.31^c	94.95^d	87.92^d	**100.18**
Mean	**112.97**	**110.80**	**106.11**	**103.10**	**99.11**	**106.41**	**112.53**	**109.21**	**102.35**	**96.90**	**90.35**	**102.26**
S.Em±	0.02	0.01	0.02	0.02	0.01	0.01	0.49	0.55	0.71	0.49	0.40	0.52
CD at 1%	0.11	0.07	0.10	0.09	0.07	0.08	2.01	2.23	2.90	2.01	1.66	2.16

Conclusion

Ozone (O_3) at the concentration of 5455.8μL L^{-1} recorded significantly least physiological loss in weight, sprouting, rotting and maximum healthy tubers retain higher moisture content and firmness. Ozone being approved as a Generally Recognized as Safe (GRAS), it can be a good option for getting classified for "organic" tag, it can store potatoes in ambient and cold storage without affecting quality and consumer acceptance. The other most important point of using ozone is that it leaves no residue after treatment and reduces chemical residues which make it a consignment most suitable for export to other countries from India.

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