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Calcium Effect on Potato Storage : Quality and Longevity at 10-12°C (CIPC)

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Abstract

The variety, Kufri Chipsona-3 observed the highest specific gravity (1.093) with 200 kg Ca ha^{-1}, significantly better than the control (1.091).The variety Kufri Bahar achieved the highest specific gravity (1.078) with 200 kg Ca ha^{-1}, followed by 1.075 at 100 kg Ca ha^{-1}, both significantly better than the control (1.073). During storage, no clear and consistent trend was observed in changes in tuber dry matter content, with variations mainly attributed to the genetic makeup of different genotypes. A calcium level of 200 kg ha^{-1}, applied as a basal dose, consistently maintained better and acceptable chip color (1.2 to 3.0) in Kufri Chipsona-3 for up to 150 days of storage at 12°C with CIPC. A similar trend, though with lower significance, was observed in the second year with 100 kg Ca ha^{-1} in this genotype. The Hunter color score improved with Ca application in storage, with Kufri Chipsona-3 achieving the highest value with 200 kg Ca ha^{-1} applied as a basal dose in the first year. In the second year, the highest score was observed with 200 kg Ca ha^{-1} applied in two splits. Calcium application did not influence reducing sugars in a consistent pattern during both years of storage. The minimum phenolic compounds (mg/100g fresh tuber weight) were obtained with 200 kg Ca ha^{-1} in two split doses in the first year, whereas in the second year, Ca nutrition had no effect.

Key words : *Potato, calcium, storage, CIPC, Biochemical constituents.*

Introduction

Calcium is essential for potato growth and development, playing a critical role in various physiological and biochemical processes. It is a key component of cell walls, contributing to cell structure and stability, which is vital for the overall strength and integrity of the plant. Calcium also influences root and tuber development, enhancing the ability of potato plants to absorb nutrients and water efficiently. Moreover, it aids in enzyme activation, signal transduction, and the regulation of various metabolic pathways. Adequate calcium levels help prevent common physiological disorders such as hollow heart and internal rust spot, leading to improved yield, quality, and storage life of potatoes. Potatoes are not a rich source of calcium (Ca) for the human diet; however, genetic variation among potato clones may benefit plant health. The primary functions of calcium in the apoplast are to maintain plasmalemma integrity and stabilize pectins both intra- and inter molecularly (1). Calcium levels in potato plants have been associated with resistance to internal brown spot (2), heat necrosis (3, 4), and infection by the soft rot pathogen as well as increased heat (5) and freezing tolerance (6). Additionally, higher levels of calcium and magnesium in cooking water have been shown to reduce sloughing (disintegration) when boiling tubers of the Russet Burbank cultivar (7). Calcium is a non-toxic mineral nutrient that plant cells can tolerate at very high extracellular concentrations. It helps maintain cell membrane and cell wall structure by forming stable yet reversible linkages between polar head groups and pectic acid fractions in the cell wall, A consistent supply of extracellular calcium is also deemed essential for cell health. Ca in the extracellular solution plays a crucial role in maintaining the selective permeability of plasma membranes. This function is partially achieved through the bridging effect of divalent calcium ions on the phosphate and carboxylate groups of phospholipid head groups at the membrane surface. Additionally, research has indicated that Ca presence in the extracellular solution enhances the bonds between the cell wall and the outer surface of the plasma membrane. In potato (*Solanum tuberosum* L.) production, soil calcium levels are generally considered sufficient. While commercial potato production guidelines recognize the essential role of Ca in plant growth, they typically assert that calcareous and/or alkaline soils, as well as irrigation waters, usually provide adequate Ca to meet plant requirements. Nitrogen is a pivotal nutrient that governs both the yield and quality of potato tubers. Imbalances— either deficiency or excess—in nitrogen elements can lead to diminished production and lower quality. Typically, only 30-50% of the nitrogen nutrients in fertilizers are absorbed by plants when applied to both dry and wet lands, with the remainder prone to leaching into groundwater or remaining in the soil. In addition to nitrogen, calcium (Ca) is a crucial mineral nutrient for potato plants. Adequate calcium levels, as noted in, can enhance the uptake of nitrogen and microelements such as iron (Fe), copper (Cu), manganese (Mn), and zinc (Zn).

Calcium and nitrogen application has been used

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mostly in other crops from agronomic point of view. But the quality parameters and long duration storage study and effect on biochemical content has not been done so far. Therefore an experiment was planned to study the impact of application of calcium and their effect on biochemical parameters of potato during storage.

Materials and Methods

Potatoes of three cultivars *viz.* Kufri Bahar, Kufri Sindhuri and Kufri Chipsona-3 from five treatments i.e. No calcium or control (T1), 100 kg Ca ha^{-1} as basal (T2), 100 kg Ca ha^{-1} in two split (T3), 200 kg Ca ha^{-1} as basal (T4) and 200 kg Ca ha^{-1} in two split (T5) were used for study. Composite samples of potatoes from each treatment were made by pooling three replications and these were then stored in plastic crates. The CIPC fog treatments were carried out in first week of April and second one in last week of May at 12^0C. Sampling was done at monthly interval up to 180 days of storage and each parameter was analysed in triplicate for processing quality parameters chip colour, specific gravity, reducing sugars and sucrose etc. Statistical analysis was done using http:www.irristat.

Results and Discussion

Biochemical analysis

Processing quality parameters : Upon thorough examination of the data, at harvest, it was observed that calcium application had a discernible impact on tuber dry matter content. For instance, in the case of K. Bahar, a moderate application rate of 100 kg Ca ha^{-1} consistently improved dry matter content over the years and in pooled means, although without reaching statistical significance. A similar trend was observed in K. Sindhuri during the second crop season and in pooled means. However, calcium nutrition did not affect the dry matter content of K. Chiposona-3, which tended to decline with higher doses. Among the cultivars, K. Chipsona-3 exhibited the highest tuber dry matter content (Table-1).

Chip color score, where 1 indicates white (most desirable) and 10 indicates black/brown (least desirable), is less significant in ware cultivars like K. Bahar and K. Sindhuri. However, for the processing variety K. Chipsona-3, it ranks as the second most important characteristic after tuber dry matter content. At a moderate calcium level of 100 kg Ca ha^{-1}, the chip color score improved significantly to 1.26 in the first year and averaged 2.16 across multiple years, compared to controls which averaged 2.43 and 2.70, respectively, at harvest time.

Internal and external defects : No internal defects such as hollow heart, brown center, or internal brown spots were detected in any of the treatments studied. Similarly, external defects like cracks and knobbiness were observed, but they did not show any significant response to calcium nutrition. External defects like cracks and knobbiness were also surveyed and showed no notable response to calcium nutrition, with trends remaining consistent compared to the previous season.

Quality during storage

Tuber dry matter content : During storage, no consistent trend was observed in the changes in tuber dry matter content, likely due to the genetic makeup of each variety. The dry matter content of the tubers also fluctuated at different stages of storage, primarily because of evaporation losses from the tuber skin inside the cold store. In the first year of the experiment, tubers treated with calcium accumulated more dry matter content compared to the control. However, in the second year, the control exhibited significantly higher dry matter content. Among the genotypes, K. Chipsona-3 consistently showed the highest mean tuber dry matter content in the first year in the second year), followed by K. Sindhuri, and K. Bahar with the lowest during the respective years.

Chip colour score : Among the three varieties, only K. Chipsona-3 was specifically released for processing purposes, while chip color was monitored in all three (Table-2). Chip color was subjectively assessed on a scale from 1 to 10, where 1 denoted highly acceptable (white), scores up to 3 were considered acceptable, and 10 indicated unacceptable (brown/black).

Mean chip color values indicated that different calcium treatments did not affect this quality parameter during the initial phase of the experiment in the first year. A basal application of 200 kg ha^{-1} calcium maintained consistent chip color (1.2 to 3.0) in K. Chipsona-3 within acceptable limits for up to 150 days in storage with CIPC treatment. During the second year, the application of 100 kg ha-1 calcium improved chip color scores marginally for K. Chipsona-3 and K. Sindhuri.

Data from the two-year study revealed that chip color remained within acceptable limits only for K. Chipsona-3 during the first year. In the second year, consistent chip color within acceptable limits was observed only at the first sampling for K. Chipsona-3 across almost all applied treatments, including the control.

Hunter colour : The color of chips prepared from samples of all three varieties at harvest and throughout storage stages was assessed using the internationally recognized Hunter Lab D 25 LT color measurement system. In the chipping variety K. Chipsona-3, mean Hunter color values showed better color in calcium-treated potatoes, with the highest value observed in T4 (200 kg Ca ha^{-1} applied as a basal dose) during the first year (Table-3).

Table-1 : Effect of different treatments on dry matter content (%) of potato tubers during storage at 12°C with CIPC.

Variety	Treat-ment	Days of storage													
		0		30		60		90		120		150		180	
		Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
K. Bahar	1	20.1	20.3	18.3	17.8	13.9	17.4	16.1	18.7	18.1	17.7	15.2	18.6	17.8	17.9
	2	20.8	18.8	18.8	19.8	17.2	17.6	17.1	18.2	15.9	17.0	14.7	16.8	15.0	16.6
	3	20.3	21.9	17.4	17.6	17.1	18.2	18.7	18.1	16.7	19.2	13.3	15.9	16.8	15.9
	4	18.3	18.3	16.0	16.8	18.0	20.9	19.5	18.4	17.2	19.7	17.7	16.1	18.6	15.8
	5	18.9	20.4	18.3	17.3	18.2	17.2	16.2	17.6	16.6	16.5	18.5	17.4	18.1	17.3
K. Sindhuri	1	18.8	18.2	13.0	16.1	18.0	18.8	13.7	18.8	17.3	19.2	18.3	17.4	19.6	17.3
	2	18.0	18.8	17.2	17.8	16.4	19.1	18.0	18.2	17.5	18.2	14.2	16.7	14.8	16.5
	3	15.9	18.4	17.1	19.4	19.6	18.6	17.5	17.7	12.2	17.4	14.1	14.7	18.1	12.6
	4	16.5	18.9	17.5	16.6	17.3	16.7	16.2	17.0	15.5	15.8	13.4	16.7	18.7	15.3
	5	17.8	18.9	17.4	16.0	14.7	19.7	15.4	18.5	14.4	12.9	14.5	17.3	19.6	17.5
K. Chipsona-3	1	20.4	18.3	16.3	16.3	17.5	17.1	17.4	20.7	15.0	17.4	12.4	20.1	19.7	20.1
	2	18.8	18.6	17.4	17.6	16.9	20.2	16.0	18.3	17.8	18.9	19.6	19.0	20.0	17.5
	3	18.2	18.5	19.7	18.2	17.8	20.5	20.2	20.6	20.0	20.0	19.7	19.8	19.5	18.4
	4	20.3	19.4	206	19.5	16.3	17.8	17.1	19.8	20.3	20.9	20.5	19.6	20.7	20.9
	5	19.6	17.3	20.5	17.4	15.8	18.0	20.4	18.6	21.2	20.6	20.9	20.2	20.1	21.8

LSD (0.05) V=0.3 V×DOS=0.8 T= 0.4 T×DOS=1.0 V×T=0.7 V×T×DOS=1.8 DOS=0.5
LSD (0.05) V= 0.2 V×DOS=0.6 T= 0.3 T×DOS=0.8 V×T=0.5 V×T×DOS=1.4 DOS=0.4

Table-2 : Effect of different treatments on potato chip colour score during storage at 12°C with CIPC.

Variety	Treat-ment	Days of storage													
		Days of storage (On a scale of 1-10, where 1 is white and 10 is black/ brown, and a score up to 3 is considered as acceptable)													
		0		30		60		90		120		150		180	
		Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
K. Bahar	1	4.30	5.50	5.40	8.50	4.70	7.30	6.10	6.70	5.70	8.00	5.00	7.50	6.00	7.00
	2	6.00	6.00	4.90	8.30	5.40	8.20	5.20	7.60	5.40	6.80	5.30	7.06	6.20	7.00
	3	5.00	5.00	5.10	7.20	4.90	9.00	5.50	8.40	5.40	7.30	5.50	7.00	6.20	7.80
	4	4.80	6.00	5.50	9.40	5.30	7.50	5.10	7.60	5.20	7.80	5.40	7.40	6.30	8.00
	5	4.90	5.50	5.00	8.30	5.70	8.30	5.10	7.50	5.00	7.40	4.10	6.50	6.60	7.40
K. Sindhuri	1	4.00	5.50	5.40	8.60	5.20	8.60	5.10	8.20	5.00	8.00	5.30	8.00	6.10	7.50
	2	3.70	4.50	4.80	8.50	5.40	7.50	4.10	7.80	5.00	7.20	5.50	7.80	5.40	6.00
	3	4.10	5.00	5.00	7.30	4.90	6.70	5.10	8.30	5.20	7.60	5.30	8.00	5.50	7.50
	4	5.00	4.00	4.30	6.40	5.00	6.00	5.30	8.20	5.40	8.10	5.30	7.00	5.80	6.80
	5	4.90	9.60	5.10	9.40	5.30	7.00	5.30	8.00	5.30	7.50	6.00	8.00	5.50	7.60
K.Chipsona-3	1	2.40	2.00	1.60	5.60	1.80	5.30	2.00	4.80	3.70	5.50	3.10	4.80	3.00	4.00
	2	1.30	1.10	2.00	5.00	2.20	2.80	3.10	5.10	2.00	4.80	3.20	6.00	3.40	4.50
	3	1.80	1.80	1.30	6.00	3.10	5.50	2.80	4.70	2.60	5.00	2.20	5.00	3.20	5.00
	4	2.60	1.90	1.20	4.80	1.50	3.60	2.90	5.50	2.60	5.60	3.00	4.30	3.40	6.00
	5	1.60	1.20	1.30	5.00	1.80	4.10	3.00	5.60	3.10	5.20	3.60	5.20	3.30	4.50

LSD (0.05) V=0.7 V´DOS=0.2 T= NS T´DOS=0.3 V´T=0.2 V´T´DOS=0.4 DOS=0.1
LSD (0.05) V=0.7 V´DOS=NS T= NS T´DOS=NS V´T=NS V´T´DOS=NS DOS=1.0

This treatment consistently maintained higher Hunter color scores (>60.0) throughout the storage period. Among the three varieties studied, K. Chipsona-3 achieved the highest Hunter color score (60.9), followed by K. Sindhuri (49.4) and K. Bahar (49.2). In the second year, calcium application generally improved HCS, especially significantly above 100 kg Ca ha^{-1}. The highest HCS (40.9) was recorded with 200 kg Ca ha^{-1} applied in two equal splits to the potato crop, significantly surpassing the control (39.0). Among the cultivars, K. Chipsona-3 achieved the highest HCS (49.7), markedly better than K. Sindhuri (36.8) and K. Bahar (34.6).During storage, the trend of HCS for K. Bahar and K. Sindhuri showed clear degradation compared to their values at harvest. In contrast, K. Chipsona-3 maintained consistent HCS (47.4-53.8) throughout storage, compared to its value of 44.3 at harvest.

Reducing sugars : In the first year of the study, tubers treated with calcium accumulated higher levels of

Table-3 : Effect of calcium on hunter colour score of potato chips during storage at 12°C with CIPC.

Variety	Treat-ment	Days of storage 0		30		60		90		120		150		180	
		Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
K. Bahar	1	56.2	39.6	41.7	30.5	48.2	31.6	53.8	31.6	44.0	28.1	39.1	40.7	51.5	36.8
	2	49.6	36.9	53.4	33.0	39.5	32.2	47.5	33.0	48.9	32.9	40.5	35.2	55.5	37.0
	3	53.6	43.7	49.7	40.5	36.4	33.9	49.7	30.0	51.7	33.5	38.8	37.8	67.5	30.1
	4	49.9	39.9	42.6	25.7	41.6	30.6	55.5	31.8	56.6	31.2	57.6	35.2	54.9	31.5
	5	52.1	42.6	44.0	37.2	45.5	30.5	57.1	30.9	51.2	31.6	47.7	43.9	49.9	38.4
K. Sindhuri	1	52.7	56.0	47.2	29.8	40.0	29.9	44.8	28.3	49.3	31.9	44.9	35.0	51.1	35.2
	2	54.2	59.5	49.1	33.8	46.5	33.1	49.1	37.7	59.1	33.2	44.3	31.9	51.3	37.7
	3	53.5	60.3	51.8	34.9	45.1	40.5	50.9	30.2	53.2	28.9	46.6	32.1	48.8	35.8
	4	52.5	57.4	48.1	42.9	49.1	29.7	45.2	29.5	63.6	31.3	53.4	38.1	49.2	41.8
	5	47.5	52.2	46.7	29.7	43.1	36.8	49.6	27.5	58.2	29.4	40.3	31.8	49.8	33.1
K. Chipsona-3	1	57.9	36.3	58.7	46.3	59.7	47.2	56.8	49.7	59.6	48.6	62.4	57.2	59.3	56.2
	2	62.8	46.8	64.3	49.2	55.2	57.0	58.2	41.3	67.3	50.1	57.4	46.8	59.7	54.7
	3	54.4	37.0	62.3	45.6	60.1	52.5	54.1	48.8	62.6	50.7	59.8	52.4	66.7	48.4
	4	62.1	53.4	66.0	45.6	61.5	57.5	57.2	45.9	64.0	45.6	58.0	57.0	61.0	47.9
	5	61.6	48.3	64.9	50.5	63.2	54.6	61.8	53.2	60.7	47.8	60.6	52.8	68.3	56.0

LSD (0.05) V= 0.0062 V´DOS=0.17 DOS=0.0096 T=0.008 T´DOS=0.21 V´T=0.140 V´T´DOS=0.3
LSD (0.05) V= 0.0076 V´DOS=NS DOS=0.0082 T=0.006 T´DOS=0.24 V´T=0.149 V´T´DOS=0.27

Table-4 : Effect of calcium on reducing sugars (mg/100 g fresh tuber weight) of tubers during storage at 12°C with CIPC.

Variety	Treat-ment	Days of storage 0		30		60		90		120		150		180	
		Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
K. Bahar	1	168.8	164.0	190.4	95.1	134.1	295.2	137.5	281.6	88.4	339.4	249.2	574.1	184.2	486.1
	2	193.3	152.9	122.4	151.9	160.1	288.2	130.0	207.0	128.5	411.9	289.8	363.5	184.4	496.7
	3	188.9	142.1	163.4	151.9	139.4	375.5	135.7	288.5	139.9	424.4	328.3	471.8	155.1	461.3
	4	193.8	164.7	185.4	152.3	172.0	286.9	150.8	190.7	112.4	363.5	336.0	492.8	184.3	438.5
	5	194.0	151.6	222.4	152.5	179.8	320.9	148.6	187.5	120.5	319.2	316.0	430.5	179.0	436.5
K. Sindhuri	1	182.0	164.6	123.2	151.6	131.8	157.3	95.7	227.9	96.4	318.6	325.6	307.4	99.2	417.8
	2	85.4	164.1	202.2	152.1	180.6	173.4	126.7	163.9	90.3	302.0	213.3	334.9	184.3	454.5
	3	101.9	165.1	238.6	153.4	160.5	207.0	118.0	127.3	125.4	320.8	229.8	430.8	184.5	440.3
	4	194.1	164.9	235.0	153.4	173.7	121.0	111.9	205.7	106.3	446.5	283.8	309.1	173.4	465.3
	5	193.1	162.9	149.7	152.4	122.5	99.6	115.8	170.1	132.0	338.9	286.8	350.1	182.4	341.4
K. Chipsona-3	1	152.8	43.3	37.4	77.7	33.2	72.6	21.3	21.3	16.5	150.6	25.2	134.2	57.8	94.4
	2	49.6	25.6	28.1	53.4	13.6	127.4	35.9	22.7	35.6	52.1	141.2	54.3	97.5	103.7
	3	135.3	22.1	34.2	51.0	14.5	113.6	21.8	41.0	34.9	125.8	18.8	89.9	87.0	84.2
	4	77.5	53.4	34.6	80.2	17.9	33.2	39.8	34.5	28.1	85.7	192.2	134.6	100.5	108.8
	5	85.9	61.7	49.4	37.9	18.5	66.0	37.6	55.5	26.1	101.2	50.5	79.8	104.8	71.8

LSD (0.05) V=4.8 V´DOS=12.7 DOS=7.4 T= 6.2 T´DOS=16.4 V´T=10.8 V´T´DOS=28.5
LSD (0.05) V=7.8 V´DOS=20.6 DOS=11.9 T= 10.1 T´DOS=26.6 V´T=NS V´T´DOS=46.2

reducing sugars (mg/100g fresh tuber weight) compared to the control, with the maximum observed in the T4 treatment where calcium was applied at 200 kg ha^{-1} as a basal dose. Mean values for sugar accumulation showed a gradual decrease up to 120 days, peaked at 150 days, and then declined by 180 days (Table-4).

Conversely, applying calcium at 200 kg ha^{-1} in two equal splits during 2009-10 resulted in the lowest accumulation of reducing sugars.Among the cultivars, the processing variety K. Chipsona-3 had the lowest reducing sugar levels (55.9 and 73.2) followed by K. Sindhuri (164.5 and 251.9) and K. Bahar (180.2 and 306.0) in Ist year and IInd year, respectively. These fluctuations in mean reducing sugar content during storage may be attributed to physiological and biochemical changes associated with dormancy breaking in different genotypes, as well as their suppression through CIPC.

Sucrose : During the first year, the mean values of Ca treatment showed that all treatments, except T4 (200 kg Ca ha^{-1} as a basal dose), resulted in higher sucrose levels (mg/100g fresh tuber weight) compared to the control (Table-5).

Table-5 : Effect of Calcium on sucrose content (mg/100 g fresh tuber weight) of tubers during storage at 12°C with CIPC.

Variety	Treat-ment	Days of storage													
		0		30		60		90		120		150		180	
		Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
K. Bahar	1	207.0	305.5	188.2	278.4	177.3	321.7	139.6	178.3	248.1	82.5	262.6	177.8	598.0	75.9
	2	253.9	241.7	193.1	297.5	151.0	329.2	161.0	185.3	175.0	107.8	296.1	150.6	844.7	235.2
	3	292.2	209.9	145.7	243.1	129.9	301.0	163.8	152.4	119.4	75.7	273.0	150.6	781.2	221.5
	4	284.3	199.1	191.0	312.0	128.2	282.1	158.8	246.3	144.8	134.6	310.4	221.3	896.4	231.7
	5	195.8	200.6	223.1	309.8	128.5	239.8	189.5	245.1	146.6	88.8	323.7	193.8	617.5	269.8
K. Sindhuri	1	172.2	231.1	196.9	242.4	129.3	214.9	128.1	133.2	118.2	128.7	248.3	218.4	634.1	254.3
	2	181.9	236.2	222.9	314.9	153.8	205.9	102.0	164.9	123.3	132.5	249.2	267.2	834.8	205.3
	3	171.5	234.3	238.5	258.3	129.4	248.1	90.1	104.0	137.0	121.6	230.3	245.9	1089.0	264.3
	4	195.9	549.6	208.5	212.1	141.8	212.9	140.1	172.5	133.8	136.6	253.6	167.0	701.4	181.0
	5	203.6	377.4	187.2	245.5	148.6	218.4	139.1	147.8	158.6	120.3	243.9	172.2	868.2	182.3
K. Chipsona-3	1	200.4	230.1	210.0	297.8	162.4	240.8	124.4	121.9	164.8	130.4	366.5	213.6	614.7	178.9
	2	224.6	241.5	171.5	278.9	146.3	307.2	155.8	112.8	199.6	123.3	388.7	214.1	1132.7	158.5
	3	2.6.0	241.2	246.4	211.1	151.8	250.9	150.0	125.7	167.6	111.4	275.8	235.4	835.4	169.3
	4	170.3	237.8	207.2	250.9	147.3	232.6	169.2	146.0	169.4	132.7	291.5	189.8	758.0	184.5
	5	267.3	317.6	197.0	230.5	144.3	269.5	178.5	267.8	202.3	114.1	411.9	192.2	1083.0	202.1

LSD (0.05) V=13.0 V´DOS=19.9 DOS=19.9 T= 16.8 T´DOS=44.4 V´T=29.1 V´T´DOS=76.9
LSD (0.05) V=6.8 V´DOS=17.9 DOS=10.4 T=8.8 T´DOS= 23.2 V´T=15.2 V´T´DOS=40.2

Table-6 : Effect of calcium on phenol content (mg/100 g fresh tuber weight) of tubers during storage at 12°C with CIPC.

Variety	Treat-ment	Days of storage													
		0		30		60		90		120		150		180	
		Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
K. Bahar	1	118.3	57.1	50.1	47.2	101.4	65.7	86.8	57.9	65.6	112.6	56.7	75.9	226.7	109.9
	2	83.1	67.6	51.6	54.4	102.2	47.1	82.5	31.1	62.0	135.8	56.0	97.6	203.3	93.6
	3	116.2	38.8	33.7	84.3	126.2	60.8	83.0	35.5	73.9	104.9	61.4	92.4	175.2	115.9
	4	89.1	48.8	44.1	85.8	140.9	34.8	84.1	43.7	70.9	113.1	68.8	96.2	189.1	78.5
	5	84.6	46.1	33.1	69.6	114.2	70.9	69.7	46.5	75.0	117.1	72.0	80.2	166.4	101.4
K. Sindhuri	1	100.8	52.7	29.3	50.8	111.8	27.2	64.7	27.4	60.4	71.3	67.5	77.4	162.4	84.5
	2	67.3	53.1	33.9	70.3	127.2	34.2	74.7	32.5	55.4	66.1	60.2	70.1	193.6	75.1
	3	78.5	55.4	40.3	66.8	109.6	43.6	68.5	32.6	69.5	81.8	71.7	78.8	161.4	86.3
	4	114.6	53.4	29.2	61.2	106.6	55.9	57.8	36.7	55.4	79.9	62.1	75.9	141.6	87.3
	5	79.6	49.4	36.5	79.5	123.2	35.3	65.1	48.7	67.3	67.1	61.7	65.5	182.9	77.9
K. Chipsona-3	1	69.6	50.2	44.7	54.5	94.4	39.5	57.5	51.1	56.0	61.6	59.8	57.2	100.6	83.4
	2	61.5	54.5	42.1	48.9	109.0	32.4	45.6	23.8	64.2	59.9	50.8	64.0	144.5	52.6
	3	65.7	46.6	43.3	40.3	97.6	35.9	55.4	36.0	38.8	50.1	53.1	60.3	146.9	65.7
	4	71.1	55.3	38.3	41.9	118.5	34.1	59.2	23.6	46.7	41.2	65.7	88.5	154.5	72.0
	5	78.1	49.2	47.8	47.4	86.2	35.6	53.7	47.0	49.7	55.2	64.1	69.4	99.4	81.0

LSD (0.05) V=2.6 V´DOS=6.9 DOS=4.0 T= 3.4 T´DOS= 6.9 V´T=5.8 V´T´DOS=15.4
SD (0.05) V=1.9 V´DOS=4.9 DOS=2.8 T= NS T´DOS=6.4 V´T=4.2 V´T´DOS=11.1

Among the three varieties, the minimum mean sucrose value was observed in K. Sindhuri (265.9), followed by K. Bahar (278.3), with the highest in K. Chipsona-3 (305.5). Sucrose content decreased after 60 days of storage, began increasing again from 150 days (295), and reached a very high level (819.3) at the 180-day storage stage. In the second year, Ca levels generally increased sucrose content, except for the dose of 100 kg Ca ha-1 applied in two equal splits (197.2).

The highest sucrose content (219.2 mg) was observed with 200 kg Ca ha^{-1}, significantly higher than the control (200.8). K. Chipsona-3 had the lowest sucrose content (204.7) compared to K. Sindhuri (214.9) and K. Bahar (214.2), which had comparable values.The mean sucrose content decreased consistently during the storage period up to 120 days (116.1) compared to the values at harvest (270.24), and then increased again up to 180 days (201.0). Genotypic behavior showed variations: K. Bahar exhibited an initial increase in sucrose content up to 60 days, a decline up to 120 days, and a sharp rise thereafter; K. Sindhuri's sucrose level decreased up to 120 days and then started increasing; and in K. Chipsona-3, the pattern was similar up to 60 days, with a decline up to 120 days and an increase afterward.

Phenols : In the first year, the minimum phenolic compounds (mg/100g fresh tuber weight) were obtained in treatment T5 (200 kg Ca ha^{-1} in 2 split doses) compared to the control. When comparing the means for individual varieties, the lowest value of phenols was observed in K. Chipsona-3 (72.4), followed by K. Sindhuri (85.5), with the highest in K. Bahar (94.8). The phenolic content did not follow a consistent trend over the storage period. In contrast, phenol content was not influenced by variations in Ca application during the second year. The variety K. Chipsona-3 recorded the lowest phenol content (51.7), which was significantly lower than K. Sindhuri (60.3) and K. Bahar (74.8). Mean phenol values declined at 60 and 90 days, with a distinct increase noticed later on. Varietal behavior was also more or less similar during the storage period (Table-6).

Conclusion

The variety Kufri Chipsona-3 exhibited the highest specific gravity (1.093) with 200 kg Ca ha^{-1}, outperforming the control (1.091). During storage, tuber dry matter content showed no consistent trend, largely due to genetic differences. A calcium level of 200 kg ha^{-1}, applied as a basal dose, maintained acceptable chip color (1.2 to 3.0) in Kufri Chipsona-3 for up to 150 days at 12°C with CIPC. The Hunter color score improved with Ca application, with the highest value achieved with 200 kg Ca ha^{-1} as a basal dose in the first year and in two splits in the second year. Calcium application did not consistently affect reducing sugars during storage. The lowest phenolic compounds were obtained with 200 kg Ca ha^{-1} in two splits in the first year; in the second year, Ca nutrition had no effect on potato internal and external defect.

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