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Sprouting Behaviour and Changes in Carbohydrate and Protein in Post-Harvest Kinetin-Treated Potatoes

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'Kufri Chandramukhi' potatoes after keeping them in a cold storage at 0.2 C for 5-7 months were dipped in solutions of kinetin and allowed to sprout at 27 +3 and 42+2 C. The data on sprouting, % CPWL and changes in starch, sugars, protein, ascorbic acid, a-amylase and protease activities were collected at uniform interval. Kinetin treatment was ineffective in controlling sprouting and sprout growth but caused slight check over % CPWL. None of the kinetin treatments controlled the breakdown of biochemical constituents.

Key Words- Cold-storage Kinetin Protein Sprouting Amylase Ascorbic acid

A number of cytokinins are of wide occurrence in plants and microorganisms. They have wide applications in storage physiology (Zink, 1961; Dedolph *et al*, 1962; Smock *et al*, 1962; Abdel-Rahman & Isenberg, 1974). Application of cytokinins such as benzyladenine and kinetin has been made mainly on leaves (Richmond & Lang, 1957; Mothes *et al.*, 1959; Sugiura *et al.*, 1962) and is reported to delay chlorophyll degradation and senescence of leafy vegetables (Leopold & Kawase, 1964) and cucumbers (Fletcher & McCulloch, 1971). Zink(1961) observed that cytokinins suppress respiration and ethylene production, retard the loss in weight, ascorbic acid, sugars, amino acids, etc. in Brussels sprouts, sprouting broccoli, mustard greens, radish tops, celery, green onions and asparagus. However, no study has been done on potatoes treated with kinetin to control tuber senescence. In the present paper, effects of kinetin on the storage behaviour of potatoes are reported.

MATERIALS & METHODS Seed tubers of *Solanum tuberosum* cv. 'Kufri Chandramukhi' were obtained from Central Potato Research Institute(CPRI), Modipuram, U.P. Potato tubers were sown in 12 experimental beds each of 1x3m in the University Botanical Garden in November, 1983 and were harvested in March, 1984.

The potatoes held in a cold storage at 0-2 C for 5-7 months were brought to the laboratory and subjected to kinetin dip treatment. Kinetin 10 and 20 ppm treated potatoes were subsequently stored at 27 ± 3C for 30 days while 100 and 200 ppm treated tubers were kept at 42± 2C for 21 days.

Per cent weight loss (% CPWL) after storage =[(X-Y)/X] x 100

Where, X = Initial weight of potato,

Y = Weight of potato on the day up to which the % CPWL is to be calculated.

The soluble sugars and starch (Hart & Fisher 1971) a-amylase activity (Bernfeld's 1951), proteins (Lowry *et al.* 1951) protease (Yomo & Varner 1973; Jhnen 1976) and ascorbic acid (Aberg, 1958) were estimated.

RESULTS Results are summarized in Plate 1 and Tables 1-6. In Tables 1-3, data were recorded from potatoes subjected to 10 and 20 ppm kinetin treatment and their subsequent storage at room temperature (27 ± 3 C) for 30 days. The potatoes were earlier kept in low temperature storage for 230 days (7 months at 0-2 C followed by 20 days at 8-10 C) immediately after harvest.

Tables 4 and 5 exhibit the data of various analyses after 100 and 200 ppm kinetin treatments followed by the storage at room temperature (42 ± 2 C) for 30 days. The tubers were earlier stored in cold storage (0-2 C) for 5 months.

Sprouting - Kinetin treatments (10,20,100 and 200 ppm) were not effective to check either sprouting or sprout growth (Fig. 1). Sprouting was initiated after 4 days.

Per cent cumulative physiological weight loss (% CPWL)-CPWL values were slightly lower in kinetin-treated (10 and 20 ppm) potatoes than in the control,

Table-1 *Solanum tuberosum* showing cumulative Physiological Weight Loss in Post-harvest Kinetin Treated Tubers (category 50-70 g) after 230 days of Store (7 months at 0-20 C followed by 20 days 8-10°C in Room Temperature (27±3°C)

	Days after				
	0-10	0-20	0 - 30	10 - 20	20 - 30
Control	1.6 + 0.1	4.9 + 0.2	7.1 + 0.1	2.8 + 0.3	2.9 + 0.2
Kinetin-					
10 ppm	2.1 + 0.1	3.8 + 0.2	6.2 + 0.2	1.8 + 0.2	2.5 + 0.3
20 ppm	2.0 + 0.1	3.9 + 0.1	6.7 + 0.2	2.0 + 0.1	2.9 + 0.1

Tuber harvested in March, 1983

Table-2 *Solanum tuberosum* Showing Starch and Sugars (in mg/100 mg dry wt. + S.E) and Specific Activity of ∝-amylase (in per mg protein basis +SE), in Post-harvest Kinetin Treated Potatoes (weight Category 50-70 g) after 230 days of storage (7 months at 0-2 C followed by 20 days at 8-10 C) at Different Intervals in Room Temperature (27 + 3 C).

				10-Day			20-Day			30-Day		
			Start	Kinetin treated			Kinetin treated			Kinetin treated		
				Control	10 ppm	20 ppm	Control	10 ppm	20 ppm	Control	10 ppm	20ppm
Starch	Cortex	(C)	56. ±1.4	38 ±2	33 ±1.08	36 ±1.11	28 ±1.19	28 ±1.61	31 ±0.66	26 ±0.97	26 ±1.55	23 ±1.43
	Pith	(P)	46. ± 1.6	35 ±3.	31 ±1.4	33 ±0.9	27 ±0.9	25 ±0.8	26 ±0.8	24 ±1.6	22 ±1.2	20 ±1.0
Total Sugars		(C)	5 ±0.2	8 ±0.20	7 ±0.2	7 ±0.2	10 ±0.3	11 ±0.2	10 ±0.2	11 ±0.3	12 ±0.2	12 ±0.3
		(P)	7 ±0.2	9 ±0.1	9 ±0.1	9 ±0.4	11 ±0.2	11 ±0.1	11 ±0.2	12 ±0.3	13 ±0.3	13 ±0.3
Reducing Sugars		(C)	3 ±0.31	4 ±0.1	4 ±0.1	4 ±0.2	5 ±0.1	4 ±0.2	4 ±0.2	5 ±0.2	5 ±0.1	5 ±0.2
		(P)	2. ±1.0	5 ±0.3	4 ±0.2	5 ±0.2	5 ±0.2	5 ±0.1	5 ±0.2	5 ±0.2	5 ±0.1	5 ±0.1
Non-reducing sugars		(C)	3	4	4	4	6	6	6	6	8	7
		(P)	5	4	5	4	6	6	6	6	8	7
Specific activity Of ∝-amylase		(C)	1 ±0	0.9 ±0.0	0.9 ±0.0	1.0 ±0.0	1.0 ±0.1	1.0 ±0.0	1.0 ±0.0	1.0 ±0.1	1.0 ±0.0	1.0 ±0.0
		(P)	1 ±0.1	0.9 ±0.0	0.9 ±0.0	0.9 ±0.1	1.0 ±0.0	1. ±0.0	1.0 ±0.0	1.1 ±0.1	1.0 ±0.0	±1.0 ±0

* Potatoes harvested in March, 1983.

Table-3 *Solanum tuberosum* Showing the amount of Protein (in mg/100 mg dry wt. + SE), Ascorbic acid (in mg/100 g dry wt.) and Protease Activity (in n.moles/mg protein basis + SE) in post-Harvest Kinetin Treated potatoes (weight category 50-70 g) after 230 days of storage * (7 months at 0-2 C Followed by 20 days at 8-10 C) at Different Intervals in Room Temperature (27 + 3 C).

			10-Day			20-Day			30-Day		
					Kinetin treated		Kinetin treated			Kinetin treated	
			O-day	Control	10 ppm	20 ppm	Control	10 ppm	20 ppm	Control	10 ppm	20 ppm
Protein	Cortex	(C)	3 ±0.1	1 ±0.0	1 ±0.0	1 ±0.0	1 ±0.0	1 ±0.0	1 ±0.	1 ±0	1 ±0.0	1 ±0.17
	Pith	(P)	3 ±0.1	2 ±0.1	2 ±0.0	2 ±0.1	2 ±0.1	1 ±0.0	1 ±0.0	1 ±0.1	1 ±0.1	2 ±0.1
Protease activity		(C)	154 ±8.0	92 ±1.7	100 ±6.1	105 ±9.2	105. ±6.4	103 ±8.0	134 ±9.2	116 ±6.2	110 ±8.7	126 ±8.4
		(P)	123 ±7.0	68 ±8.8	113 ±4.9	114 ±12	97 ± 2.6	103 ±17.0	133 ±11.8	104 ±6.1	109 ±17	103 ±4.3
Ascorbic acid		(C)	16.4	14.6	14.6	17.6	11	11	11	9	9	9
		(P)	18.7	13.4	14.3	20.5	10.9	9.1	12.2	10.9	12.1	10.3

* Potatoes harvested in March, 1983.

Table-4 *Solanum tuberosum* Showing % Cumulative Physiological Weight loss in Post-harvest Kinetin Treated Potatoes (Weight Category 50-70 g) After 5-month storage (0-2 C) at Different Intervals in Room Temperature (42 + 2 C)

	Days after				
	0 - 7	0-14	0 -21	7 - 14	14-21
Control	1.1 ± 0.1	2 ± 0.1	3.4 ± 0.2	1.0 ± 0.1	1.5 ± 0.12
Kinetin-treated					
(a) 100 ppm	1.0 ± 1	2 ± 1	3 ± 0.3	1.0 ± 0.1	1 ± 0.1
(b) 200 ppm	1.0 ± 0.8	1.9 ± 0.2	3.1 ± 0.2	1.0 ± 0.1	1.2 ± 0.1

* Tuber harvested in March, 1984.

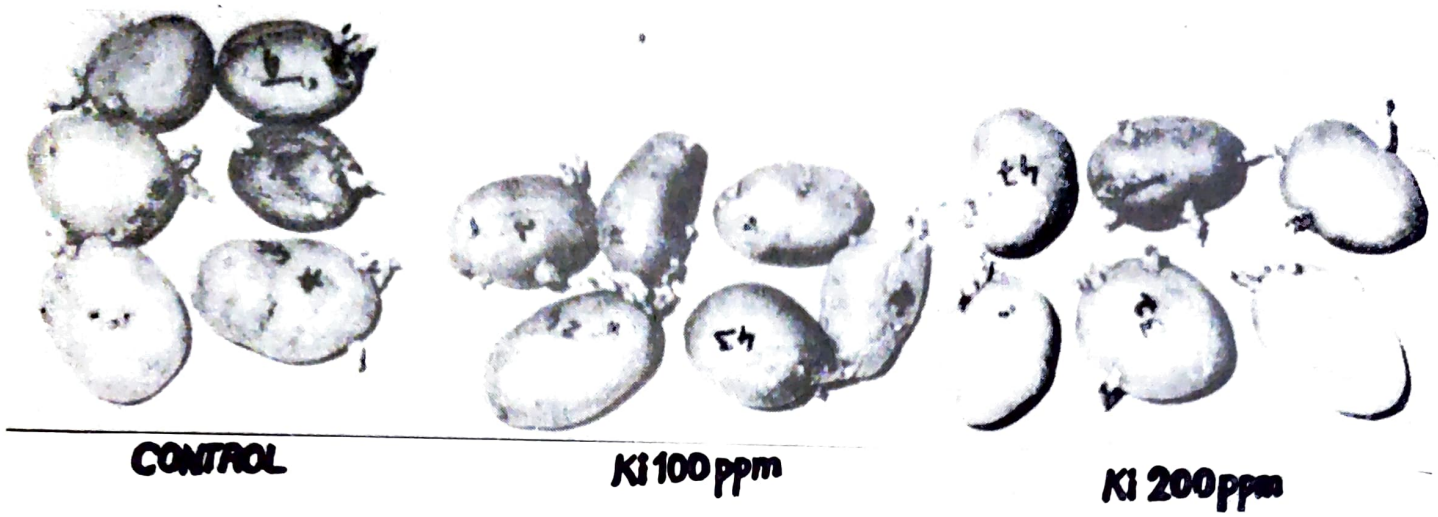

Fig. 1 Control and post-harvest kinetin-treated Potatoes (*Solanum tuberosum*) 'Kutri chandramukhi'

Table 5. *Solanum tuberosum* showing the Amount of Starch and Sugars (in mg/100g dry wt ± SE) and Specific activity of ∝ – amylase (in per mg Protein basis ± SE) in post-Harvest Kinetin treated potatoes (weight category 50-70g) after 5 month storage* (0-2°C) at Different Intervals in Room Temperature (42 ± 2C)

		7-Day			14-Day			21-Day		
			Kinetin treated			Kinetin treated			Kinetin treated	
		0-day	Control	100 ppm	200 ppm	Control	100 ppm	200 ppm	Control	100 ppm	200 ppm
Starch	Cortex (C)	66 ±3.3	57 ±4.3	58 ±1.8	58 ±5.3	50 ±5.3	51 ±3.7	52 ±4.5	38 ±4.0	39 ±2.4	39 ±2.6
	Pith (P)	57 ±3.0	52 ±2.1	53 ±4.3	53 ±3.7	48 ±4.1	48 ±2.1	50 ±3.6	37 ±2.4	38 ±4.0	39 ±1
Sugars (Total)	(C)	22 ±0.5	23 ±1.0	24 ±2.2	22 ±1.8	26 ±1.2	27 ±1.5	27 ±0.4	27 ±0.4	27 ±1.3	27 ±0.3
	(P)	20 ±0.9	23.1 ±1.2	23 ±1.6	23 ±1.3	25 ±0.5	27 ±0.7	27.2 ±1.2	27 ±0.5	27 ±0.9	27 ±0.4
Reducing Sugars	(C)	15 ±0.7	14.2 ±0.5	15 ±0.1	15 ±0.7	14 ±0.4	14 ±0.3	14 ±0.8	13 ±0.4	13 ±0.4	13 ±0.6
	(P)	14 ±0.3	14 ±0.8	14 ±0.4	14 ±0.2	13 ±0.3	13 ±0 5	14 ±0.4	13 ±0.4	13 ±0.3	13 ±0.3
Non-reducing sugars	(C)	7.0	9	9	7	12	13	13	15	14	14
	(P)	6.3	9.5	9.4	10.2	12.4	13.1	12.2	13.9	14	13.3
Specific activity of α-amylase	(C)	0.2 ±0.0	0.4 ±0.0	0.4 ±0.0	0.4 ±0.0	0.7 ±0.0	0.7 ±0.0	0.7 ±0.0	1.0 ±0.0	1.0 ±0.0	1.0 ±0.1
	(P)	0.2 ±0.1	0.4 ±0.1	0.4 ±0.0	0.4 ±0.0	0.8 ±0.1	0.7 ±0.1	0.7 ±0.1	1.0 ±0.0	1.0 ±0.0	1.0 ±0.1
Ascorbic acid	(C)	23 ±1.0	18 ±0.4	20 ±1.2	22 ±0.4	14 ±0.3	15 ±0.6	15 ±0.3	13 ±1.4	14 ±0.6	13 ±1.0
	(P)	27 ±0.3	22 ±1.0	25 ±1.5	25 ±1.8	16 ±0.4	22 ±0.4	23 ±0.7	15 ±0.4	18 ±0.2	18 ±0.5

* Potatoes harvested in March, 1984.

specially after a period of 20 and 30 days (Table 1). In control, CPWL value became almost double during 10-20 day period, compared to the 0-10 day and the degree of loss was the same thereafter. In treatment potatoes, maximum increment was recorded between 20-30 days.

Application of kinetin at 100 and 200 ppm also did not bring significant difference in % CPWL but the values were slightly lower in the treated than in the untreated potatoes (Table 4).

Carbohydrates- *Starch* - After low temperature storage for 230 days, when potatoes were transferred to room temperature (27 ±3C) the initial values of starch were 56 and 46 mg/100 mg dry weight in cortex and pith regions, respectively. More than 50% decline in starch occurred during 30-day storage. Both 10 and 20 ppm did not control starch breakdown (Table 2).

Even 100 and 200 ppm kinetin treatment failed to check the starch breakdown in potatoes (Table 5).

Sugars - In one of the experiments, total sugars increased twice after 30 days in the treatment and control potatoes, irrespective of the tissue (Table 2). Both reducing and non-reducing sugars increased with storage period and maximum increment occurred during the first 20 days.

Another experiment conducted with 100 and 200 ppm kinetin caused more or less similar pattern of changes in sugars in the treated and control tubers (Table 5).

α-Amylase Activity- Specific activity of a-amylase increased during the storage (Tables 2 and 5). Kinetin-treated potatoes were comparable to the control.

Ascorbic Acid - The ascorbic acid values in Tables 3 and 5 clearly showed higher loss during the experimental period. The tubers held in cold storage for 7 months had lower level of ascorbic acid than the lot kept for 5 months. Per cent decline in ascorbic acid was 40-50% during room temperature storage (Tables 3 and 5). Some check in the reduction was recorded after 100 and 200 ppm kinetin treatment

Protein - Table 3 shows the protein changes in control and treated potatoes. Initially, the values were 3 and 3 mg/100 mg on dry weight basis and almost 50% declined after 30 days. Kinetin treatments, however, did not bring about any difference from the control.

Protease Activity- Protease activity declined by about 30% from the initial values of 154 and 123 n.moles/mg protein, in cortex and pith regions, respectively. Kinetin-treated potatoes, however displayed protease activity (Table 3).

DISCUSSION Results clearly indicated that kinetin application did not control the sprout initiation and sprout growth in 'Kufri Chandramukhi' potato after storage at 0-2 C for 5-7 months although, a slight check over % CPWL value was observed after treatment.

Results clearly indicated the starch breakdown even in low temperatures. When a comparison is made of a-amylase activity between the potatoes stored for 5 months at 0-2 C and immediately after harvest, a close correlation could be seen although starch content had a lower value in former case. This may indicate that the hydrolysis of starch at low temperature was not due to α-amylase which might have become inactive during this period. But, it can be attributed to the activity of the enzyme sucrose phosphate synthetase and the sucrose produced is hydrolyzed by invertase (Moorby, 1978). When potatoes shifted to higher temperatures from cold storage, starch breakdown was very high, but the per cent increment in total sugars was lower than those subjected to long term storage at room temperature. This may be explained by the fact that in the former during constant depletion of the starch, non-reducing sugars maintained a higher value and whatever has been converted into reducing sugars being readily utilized for the sprout growth and rapid respiratory activity. This is also accompanied by higher specific activity of a-amylase. In the latter case, since potatoes were analysed after 2 1/2 months (i.e., just after the dormant period when sprouts were initiated but abscised later on) which were constantly held at room temperature, the requirement of total sugars naturally diminished (in absence of sprout growth and maintenance throughout at the same temperature) resulting in higher accumulation. Ascorbic acid losses were recorded in low temperature. The decline in protein-content during a period of 30-day at room temperature was about 50%. The protein is being rapidly utilized for sprout growth. According to Burton(1978), the depletion of protein and increment in the free pool of amino acids occured during sprout growth of potatoes. However, the specific activity of protease showed about 30% decline. Oc course, the present procedure of analysis of protease activity (caseiolytic assay) included only the alkaline proteases. Kinetin treatment did not control the breakdown of various biochemical consitituents.

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Table-6 *Solanum tuberosum* showing the Amount of Starch and Sugars (in mg/100g dry wt. ±S.E.) and Specific Activity of ∝- amylase (in per mg protein basis + S.E.) in potatoes after harvest Room Temperature (42±2 C).

			Immediately after harvest	2.5 months after harvest
Starch	Cortex	(C)	7.5 + 4	63. + 3
	Pith	(P)	72. + 4	56 + 3
Total Sugars		(C)	10 + 0.1	22 + 2.
		(P)	10 + 0.1	21 + 3.5
Reducing Sugars		(C)	4 + 0	15 + 0.4
		(P)	5 + 0	13 + 1.0
Non-reducing sugars		(C)	6	8
		(P)	5	9
		(C)	107 + 6	55 + 2
Ascorbicacid		(P)	115 + 8	65 + 2
		(C)	0.2 + 0.01	0.4 + 0.02
Specific activity of amylase		(P)	0.3 + 0.01	0.5 + 0.03

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