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# Changes in processing quality of potatoes at different low holding temperatures

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## ABSTRACT

**Four potato cultivars, *viz.*, Kufri Bahar, Kufri Jyoti, Kufri Chipsona-1 and Kufri Chipsona-2 were loaded into three walk-in-chambers maintained at 20°C and the temperature was lowered by 0.5°C per day until the holding temperatures of 12, 8 and 4°C were reached. There was a decrease in the reducing sugar content in all the four cultivars by the time the temperature reached 12°C. However, it increased with further lowering of the temperature to 8 and 4°C. Dry matter and phenols content also increased in all the four cultivars by the time the temperatures reached 12, 8 and 4°C, while sucrose content decreased. After 120 days of storage (DOS), the reducing sugar content ranged from 191-259, 239-235 and 612-718 mg/100 g f.w. at 12, 8 and 4°C, respectively, resulting in deterioration in chip colour. Dry matter, sucrose and phenols content also increased after 120 DOS. The results showed that reducing sugars content increased by the time the holding temperatures of 8 and 4°C were reached.**

**Key words:** *Solanum tuberosum*, processing quality, holding temperature, storage, CIPC.

## INTRODUCTION

Potato is grown in plains of North India during winter and the produce harvested in February-March is stored in cold store at 2-4°C and 90-95% RH. Stored potatoes are utilized for table purpose from May to October. Traditionally, potatoes are being stored in India at 2-4°C and at this temperature potatoes accumulate sugars and develop a sweet taste. Due to excessive sugar accumulation cold stored potatoes are not suitable for processing (Smith, 13; Verma, 17). Potatoes meant for processing are generally stored at around 10°C with CIPC (isopropyl N-(3-chlorophenyl) carbamate) to suppress sprout growth (Es Van and Hartmans, 2; Burton, 1). Potatoes enter the cold store at a relatively higher temperatures prevailing at harvest and it needs to be lowered gradually by 0.5°C per day, until the desired holding temperature (4-12°C) is reached. Storage studies have been carried out recently by storing potatoes at different temperatures with CIPC treatment (Ezekiel *et al*., 5). However, information on the sugar concentrations at the time of loading and at the time when the holding temperature is reached, and during subsequent storage period is lacking. The aim of this investigation was to collect information on these aspects.

## MATERIALS AND METHODS

Four potato cultivars, *viz*., Kufri Bahar, Kufri Jyoti, Kufri Chipsona-1 and Kufri Chipsona-2 were grown at Central Potato Research Station, Jalandhar during 2006-07. Planting was done in the first week of October 2006 and harvested in the last week of January, 2007. The crop was raised following recommended package of practices. Haulms were cut at crop maturity and harvesting was done 15 days later to allow skin set. Harvested tubers were cured at Central Potato Research Institute, Shimla. The tubers were stored in three walk-in-chambers at 4, 8 and 12°C. The RH maintained was 90-95% at 4°C and 85-90% at 8 and 12°C. Potatoes stored at 8 and 12°C were treated with CIPC to suppress sprout growth. The potatoes were loaded into walk-in-chambers set at 20°C and the temperature was brought down by 0.5°C per day until the desired holding temperature was reached. The commercial preparation of CIPC called "Oorja" (United Phosphorus Ltd., Mumbai) containing 50% active ingredient (a.i.) was applied twice @ 35 ml per tonne of potatoes using a fogging machine (Dyna fog, USA). The first application was done on 12th May, 2007 and the second on 4th July, 2007. Dry matter, reducing sugars, sucrose, phenols and chip colour were determined at the time of loading, the day the desired holding temperature of 4, 8 and 12°C was reached and after 120 days of storage (DOS) at different temperatures.

Ten tubers were drawn randomly from each replication, washed, hand peeled and cut longitudinally into two halves. One half was used for preparing chips and the other half for analysis. For preparing chips, the tubers were cut into 1.75 mm thick slices using an automatic slicer (Wintech Taparia, Indore). The slices

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were washed in normal water at room temperature (24-26°C) to remove surface starch and were dried on paper towels for 2 min. The dried slices were fried in cotton seed oil at 180°C in a deep fat fryer till the bubbling stopped. The fried chips were drained to remove excess oil and then scored on a scale of 1 to 10 (1 being the lightest and 10 the darkest, the chip colour grade up to 4 is considered acceptable) under the fluorescent tube light using the chip colour cards (Ezekiel *et al*., 4). Tuber halves were diced and used for biochemical analysis. Dry matter content was determined by drying 50 g of diced tubers per replication, in an hot air oven at 80°C for 6 h and then at 65°C until constant weight was obtained. Ten gram of diced tubers were used per replication and there were three replications for each treatment. Reducing sugar content (Nelson, 10), sucrose (Van Handel, 16), and total phenols (Swain and Hillis, 15) were determined. Statistical analysis was done using MSTAT 4.0C package for computers following the method of Gomez and Gomez (7).

## RESULTS AND DISCUSSION

Dry matter content of potatoes is important from processing point of view because higher dry matter content results in higher chip yield. The dry matter content was higher in Kufri Chipsona-1 and Kufri Chipsona-2 and lower in Kufri Jyoti and Kufri Bahar (Table 1). Kufri Chipsona-1 and Kufri Chipsona-2 are known to have higher dry matter content (Kumar and Ezekiel, 8). The dry matter content increased during storage, and the increase was considerable after 120 DOS. Increase in dry matter content by the time the desired temperature was reached was proportional to the time taken to reach that temperature. The increase was non-significant at 12°C but significantly higher at 8°C. The increase was significant at 4°C in Kufri Bahar and Kufri Jyoti but not in the other two cultivars. The increase in dry matter content during storage could be attributed to moisture loss. After 120 DOS, the dry matter content was significantly higher in Kufri Bahar and Kufri Chipsona-1, as compared to that at the time of loading and at 0 day at the holding temperature. Earlier, Smith (13) reported that increase in dry matter content with increase in storage duration is the result of loss of water by evaporation.

Reducing sugar content of potatoes is the most important parameter for processing because it affects the colour of chips. A reducing sugar content of up to 150 mg/100 g f.w. is considered acceptable since such potatoes produce chips of acceptable colour. When the reducing sugar content exceeds this limit, chips show browning and therefore, become unacceptable. The reducing sugar content at the time of loading ranged from 94 to 129 mg/100g f.w. in three cultivars and was thus below the limit, but in Kufri Bahar it was 245 mg/100g f.w. and thus above the limit. It was interesting to observe a decrease in reducing sugar content by the time the desired temperature was reached. By the time 12°C was reached, there was a decrease of 2-47 mg of reducing sugars per 100g f.w., depending upon the cultivar (Table 2). By the time the temperature reached 8°C, the reducing sugar content began to increase and reached near or slightly above the initial level and when the temperature reached 4°C, the reducing sugar content was 24-68 mg higher than that at the time of

**Table 1**. Effect of holding temperature on the dry matter content (%) content of tubers of four potato cultivars.

| Cultivar | Storage temp. (°C ) | At the time of loading | 0 day at holding temperature | 120 days of storage |
|---|---|---|---|---|
| Kufri Bahar | 4 | 17.6 | 20.4 | 20.8 |
| | 8 | | 20.6 | 21.1 |
| | 12 | | 17.8 | 18.8 |
| Kufri Jyoti | 4 | 18.4 | 19.8 | 19.1 |
| | 8 | | 19.7 | 19.8 |
| | 12 | | 18.6 | 19.5 |
| Kufri Chipsona-1 | 4 | 22.4 | 22.7 | 23.0 |
| | 8 | | 23.5 | 24.1 |
| | 12 | | 22.6 | 23.9 |
| Kufri Chipsona-2 | 4 | 22.9 | 22.9 | 22.0 |
| | 8 | | 23.3 | 24.1 |
| | 12 | | 22.2 | 22.6 |

$LSD_{0.05}$ Temperature (T) = 0.33; Cultivar (C) = 0.38; Storage time (S) = 0.33; T × C = 0.65; T × S = 0.56; C × S = 0.65; T × C × S = 1.13

loading. Compared to that at the time of loading, the reducing sugar content at 0 day of holding temperature of 4°C was significantly higher in three cultivars, but in Kufri Bahar, it was significantly lower. After 120 DOS, the reducing sugar content was significantly higher at 4° and 8°C, and even at 12°C it was above the acceptable limit. The interaction between temperature and cultivar was non-significant. Increase in reducing sugar has been observed after storage at different temperatures (Richardson *et al*., 11; Burton, 1; Es Van and Hartmans, 2).

A chip colour score of up to 4 is considered acceptable and beyond it as unacceptable (Ezekiel *et al*., 4). The chip colour score ranged from 5 to 6.6 at the time of loading, it increased further by the time the desired temperature was reached, and remained high up to 150 DOS (Table 3). Thus, the chip colour was unacceptable in all the four cultivars at the time of loading and after storage. Potatoes stored at a lower temperature of 4°C are known to produce dark colour chips due to excessive accumulation of reducing sugar (Ezekiel *et al*., 3). Although, the reducing sugar

**Table 2**. Effect of holding temperature on the reducing sugars content (mg/100 g f.w.) of tubers of four potato cultivars.

| Cultivar | Storage temp (°C ) | At the time of loading | 0 day at holding temperature | 120 days of storage |
|---|---|---|---|---|
| Kufri Bahar | 4 | 245 | 220 | 718 |
| | 8 | | 224 | 329 |
| | 12 | | 196 | 259 |
| Kufri Jyoti | 4 | 129 | 168 | 675 |
| | 8 | | 141 | 355 |
| | 12 | | 114 | 234 |
| Kufri Chipsona-1 | 4 | 94 | 162 | 612 |
| | 8 | | 114 | 259 |
| | 12 | | 92 | 191 |
| Kufri Chipsona-2 | 4 | 114 | 138 | 669 |
| | 8 | | 111 | 239 |
| | 12 | | 87 | 214 |

$LSD_{0.05}$ Temperature (T) = 13; Cultivar (C) = 15; Storage time (S) = 13; T × C = NS; T × S = 22; C × S = 26; T × C × S = NS.

**Table 3**. Effect of holding temperature on the chip colour score* in tubers of four potato cultivars.

| Cultivar | Storage temp. (°C ) | At the time of loading | 0 day at holding temperature | 120 days of storage |
|---|---|---|---|---|
| Kufri Bahar | 4 | 6.0 | 7.0 | 8.0 |
| | 8 | | 7.0 | 7.0 |
| | 12 | | 6.6 | 6.0 |
| Kufri Jyoti | 4 | 6.3 | 9.0 | 8.0 |
| | 8 | | 8.0 | 7.0 |
| | 12 | | 7.0 | 7.0 |
| Kufri Chipsona-1 | 4 | 5.0 | 6.0 | 7.0 |
| | 8 | | 5.0 | 6.3 |
| | 12 | | 5.3 | 5.3 |
| Kufri Chipsona-2 | 4 | 6.6 | 7.0 | 8.3 |
| | 8 | | 7.3 | 7.0 |
| | 12 | | 5.0 | 5.0 |

$LSD_{0.05}$ Temperature (T) = 0.2; Cultivar (C) = 0.2; Storage time (S) = 0.2; T × C = 0.3; T × S = 0.3; C × S = 0.3; T × C × S = 0.5

*Scored on a scale of 1-10 of increasing darkness.

level was within the acceptable limit of 150 mg/100 g f.w. in three cultivars at the time of loading and when the temperatures of 12° and 8°C were reached, the chip colour score was high and unacceptable. Similar observation has been made by Kumar and Ezekiel (8). The unacceptable chip colour despite acceptable reducing sugar level may be due to differences in free amino acids content (Roe *et al*., 12).

Sucrose content varied from 72 to 116 mg/100 g f. w. at the time of loading and it decreased significantly by the time the desired temperature was reached (Table 4). However, after 120 DOS, it increased and ranged from 104-278 mg/ 100 g f.w. The sucrose content was less than the desirable concentration of 150 mg/100 g f.w. (Sowokinos and Preston, 14) even after 120 DOS at 12° and 8°C but was above the limit at 4°C. Among the cultivars, Kufri Chipsona-1 and Kufri Chipsona-2 showed lower sucrose levels, while Kufri Bahar had higher level. The phenols content varied from 29 to 32 mg/100 g f.w. at the time of loading. Cultivar differences were significant and it was higher in Kufri Chipsona-1 and lower in Kufri Bahar (Table 5). Except in Kufri Chipsona-1, the phenol content increased significantly by the time the desired temperatures of 12, 8 and 4°C were reached. After 120 DOS, the phenol content was

**Table 4**. Effect of holding temperature on the sucrose content (mg/100 g f.w.) of tubers in four potato cultivars.

| Cultivar | Storage temp. (°C ) | At the time of loading | 0 day at holding temperature | 120 days of storage |
|---|---|---|---|---|
| Kufri Bahar | 4 | 116 | 89 | 185 |
| | 8 | | 90 | 141 |
| | 12 | | 93 | 128 |
| Kufri Jyoti | 4 | 90 | 71 | 278 |
| | 8 | | 73 | 142 |
| | 12 | | 72 | 122 |
| Kufri Chipsona-1 | 4 | 72 | 69 | 178 |
| | 8 | | 69 | 121 |
| | 12 | | 58 | 112 |
| Kufri Chipsona-2 | 4 | 74 | 71 | 145 |
| | 8 | | 74 | 124 |
| | 12 | | 57 | 104 |

$LSD_{0.05}$ Temperature (T) = 2; Cultivar (C) = 3; Storage time (S) = 2; T × C = 4; T × S = 4; C × S = 4; T × C × S = 8

**Table 5**. Effect of holding temperature on the phenol content (mg/100 g f.w.) in tubers of four potato cultivars.

| Cultivar | Storage temp. (°C ) | At the time of loading | 0 day at holding temperature | 120 days of storage |
|---|---|---|---|---|
| Kufri Bahar | 4 | 29 | 38 | 39 |
| | 8 | | 37 | 37 |
| | 12 | | 37 | 34 |
| Kufri Jyoti | 4 | 35 | 40 | 44 |
| | 8 | | 37 | 39 |
| | 12 | | 36 | 35 |
| Kufri Chipsona-1 | 4 | 38 | 42 | 35 |
| | 8 | | 34 | 33 |
| | 12 | | 30 | 33 |
| Kufri Chipsona-2 | 4 | 32 | 37 | 37 |
| | 8 | | 36 | 26 |
| | 12 | | 35 | 32 |

$LSD_{0.05}$ Temperature (T) = 2; Cultivar (C) = 2; Storage time (S) = 2; T × C = NS; T × S = NS; C × S = 3; T × C × S: 6

generally higher than that at the time of loading. An increase in phenolic content during storage of potatoes has been reported (Swain *et al*., 15).

The study showed that when potatoes were loaded into walk-in-chambers at 20°C and the temperature was lowered by 0.5°C per day, there was a significant decrease in the reducing sugar content of three cultivars by the time the temperature reached 12°C. However, it increased with further lowering of the temperature to 8 and 4°C. Sucrose content decreased by the time the desired temperature was reached and increased subsequently after 120 DOS.

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