

# EFFECT OF DIFFERENT VARIETIES AND TUBER SIZES ON SUGAR CONTENT OF POTATO TUBERS UNDER ROOM TEMPERATURE STORAGE

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## ABSTRACT

The experiment was started on 9<sup>th</sup> March, 2012 by keeping healthy clean tubers of three different sizes for each genotype in hessian cloth bag at room temperature in four replications. Among the four varieties, Kufri Pukhraj showed the highest non-reducing sugar (175.0 mg) and Kufri Pushkar the lowest (145.7 mg). The larger potato tubers had higher sucrose content (188.8, 206.9 and 186.7 mg) as compared to smaller tubers (142.8, 166.7 and 133.8 mg) on zero, 45<sup>th</sup> and 90<sup>th</sup> day of storage respectively. The reducing sugars and total sugars of potato tubers decreased up to 45 days of storage, and thereafter, it increased continuously up to the end of the experiment. Among the sizes, both the reducing and total sugars were higher in smaller tubers than in larger ones. The maximum value for reducing sugar and total sugars was noticed in Kufri Badshah (391.3 mg, 548 mg) and minimum in Kufri Pushkar (301.4 mg, 445.3 mg) respectively at the end of the experiment.

## INTRODUCTION

Potato is an important food crop in India as well as in the world (Scott and Suarez, 2012). India has seen a revolution in potato production during recent years (Scott and Suarez, 2011). Potatoes are the fourth most important agricultural crop worldwide after wheat, corn, rice and play a key role in feeding the growing world (Fennir, 2002). Potato production in India has shown gradual and steady increase in last 50 years (Shekhawat, 2001). Potato accumulated a large amount of sugars under conditions of high temperature storage. An increase in total sugars or a particular sugar is indubitably a heritable character but is also affected by a number of environmental factors (Burton, 1989; Ezekiel *et al.*, 1999). Sugar level in potato tubers during tuberization and at harvest is largely dependent on cultivar (Sinha *et al.*, 1992). Also according to Shabba *et al.* (2007), the quantity and kind of sugars in particular cultivar are the inherited characteristics. The accumulation of sucrose in large quantities in tubers stored at high temperature or farm stores had been reported earlier (Verma *et al.*, 1974; Uppal, 1999). In potato, more than 65% of the maximal sucrose accumulation occurred within 5 days of storage since potato increased its ability to produce sucrose as the storage period increased (Sowokinos *et al.*, 1987). Kumar and Ezekiel (2006) assessed two early maturing potato cultivars, viz. the Indian var. Kufri Lauvkar and the exotic var. Atlantic, for sucrose changes during tuber growth and noted that relatively, the poor processing var. Kufri Lauvkar maintained higher sucrose content as compared to Atlantic

throughout the growth and irrespective of tuber size. They obtained a negative correlation between free sugars *vis-à-vis* crop duration and tuber size. The increase in reducing sugar contents took place subsequent to increase in sucrose content. Storage also induced a marked increase in sucrose content (Ezekiel and Singh, 2007). Kumar (2011) studied the development of cold induced sweetening and its relation with phenolic content of the tuber in three Indian potato varieties, viz. Kufri Chipsona 1, Kufri Chipsona 3, and Kufri Jyoti and observed that the reducing sugars decreased in initial phase of storage, followed by continuous increase to unacceptably higher levels after around two weeks of storage.

The reduction in reducing sugars at high temperature might be due to low activities of invertase or synthesis of invertase inhibitors (Pressey and Shaw, 1996). The exotic cultivar Atlantic and Frito Lay 1625 showed negligible accumulation of reducing sugars and invertase activities as compared to Indian cultivar Kufri Luvkar and Kufri Jyoti during storage at 6°C for 90 days, and there was a general trend of decline in content of reducing sugars and invertase activity at higher temperature (20°C) of storage (Peshin, 2000). When mature tubers were stored at relatively high temperature, the concentration of reducing sugars remained low (Rubbi *et al.*, 1988). The freshly harvested mature tubers of a few Indian potato cultivars contain low level of reducing sugars (Rai and Verma, 1989). The glucose concentration increased early in storage and then remained constant (Zhitian *et al.*, 2002). Kumar *et al.* (2003) monitored potato tubers of Kufri Chipsona

1, Kufri Chipsona 2 and Atlantic harvested in first week of February for changes in reducing sugars and sucrose content for 40 days at room temperature and noticed that reducing sugars decreased after 20 days of storage. Increase in sugar with increasing period of storage in beginning and increase in later stage is also reported by Kumari *et al.*, 2016.

A mature potato had a lower content of reducing sugars (Tineke *et al.*, 2006). Kumar and Ezekiel (2006) evaluated two early maturing potato cultivars, *viz.* the Indian cv. Kufri Lauvkar and the exotic cv. Atlantic, for reducing sugars changes during tuber growth and noted that comparatively, the poor processing cv. Kufri Lauvkar maintained higher content of reducing sugars (43.74 mg/100 g on fresh weight) as compared to cv. Atlantic (14.68 mg/100 g on fresh weight basis) throughout the growth and irrespective of the tuber size but this increase in content of reducing sugars took place subsequent to increase in sucrose content. Storey (2007) reported that potato tubers contained 0.01-0.6% reducing sugars on fresh weight basis. Ezekiel and Singh, (2007) reported that reducing sugars increased during storage and out of the seven varieties grown at Modipuram, only Kufri Chipsona 1 showed lower reducing sugars. Upon handling, the glucose content changed less markedly than sucrose but its level appeared slightly higher at most intervals as compared to control values. Storage also induced a marked increase in the sucrose content. Pandey *et al.* (2008) evaluated two potato varieties for reducing sugars and found that the tubers of Kufri Himsona had lower levels of reducing sugars and variety Kufri Jyoti higher reducing sugars (206.7 mg/100 g on fresh weight). Minimum reducing sugar was observed on the initial (0) day of storage (Kumari *et al.*, 2016).

Even when storage of potato is done under ideal conditions, losses will occur and its chemical composition will change somewhat. These losses and changes in composition relate to the product being a living one and are determined by various factors such as maturity of the tubers at harvesting and storage temperature. Keeping in view the above facts, this experiment was conducted to evaluate the effect of different sized tubers and cultivars on the changes in total sugars, reducing sugars and non reducing sugar storage under ambient conditions.

## MATERIALS AND METHODS

The present investigation was carried out in laboratory of the Department of Vegetable Sciences, CCS Haryana Agricultural University, Hisar. All the four varieties V1: Kufri Badshah, V2: Kufri Bahar, V3: Kufri Pukhraj, V4: Kufri Pushkar were harvested from Vegetable Farm, CCSHAU, Hisar. These varieties has been selected due to its wide spread adaptability to the local conditions and superior processing quality attributes. Potatoes were sorted and graded into 3 different sized tubers *i.e.*, S1: > 25-50 g, S2 : > 50-75 g and S3 : > 75 g and subsequently cured for one week (20-22°C) before being subjected to different analytical trials during storage. Potatoes were placed under ambient room conditions for three months. Maximum and minimum temperatures and relative humidity ranged between 22 to 40°C, 38 to 88% RH.

Four kg healthy clean tubers of each genotype were placed in hessian cloth bag at room temperature in four replications.

The experiment was design out in Complete Random Design (factorial) with twelve treatment combinations and four replications. The set of treatments were as follows: V<sub>1</sub>S<sub>1</sub>, V<sub>1</sub>S<sub>2</sub>, V<sub>1</sub>S<sub>3</sub>; V<sub>2</sub>S<sub>1</sub>, V<sub>2</sub>S<sub>2</sub>, V<sub>2</sub>S<sub>3</sub>; V<sub>3</sub>S<sub>1</sub>, V<sub>3</sub>S<sub>2</sub>, V<sub>3</sub>S<sub>3</sub>; V<sub>4</sub>S<sub>1</sub>, V<sub>4</sub>S<sub>2</sub>, V<sub>4</sub>S<sub>3</sub>. This similar type of materials was also used by Sharma *et al.*, 2012.

### Non-Reducing sugar

The content of non-reducing sugar was obtained by subtracting the values of reducing sugars from that of total sugars and multiplying the value with 0.95 (Somogyi, 1952) as given:

**Non-reducing sugar** = Total sugars – reducing sugars

### Reducing sugar

Reducing sugars were estimated by using method of Somogyi (1945).

### Total sugars

The total sugar was estimated by using the method of Yemm and Willis (1954).

## RESULTS AND DISCUSSION

### Non-reducing sugar (mg/100 g)

It is evident from Table 1 that all the genotypes were significantly different in terms of non-reducing sugars. During storage, the variety Kufri Pukhraj showed the significantly maximum value for non-reducing sugar (175.0 mg) closely followed by Kufri Badshah (173.3 mg), while Kufri Pushkar showed the minimum value for non-reducing sugar (145.7 mg). On 90th day of storage, Kufri Pukhraj (178.0 mg) showed the maximum value for non-reducing sugar, whereas, Kufri Pushkar showed the minimum value for non-reducing sugar (144.1 mg). Sugar level in potato during tuberization and at harvest is largely dependent on cultivar (Sinha *et al.*, 1992). Low sugar content is a desirable character for processing purpose. Some varieties have been developed for low sugars (Wilde *et al.*, 2004). Sucrose content at the time of harvest is an indicator of chemical maturity of the tuber. Lower sucrose content is desirable for long term storage at intermediate temperatures (Shallenberger *et al.*, 1959). The higher values of sucrose in potato tuber at the time of harvest indicate its immaturity. The sucrose content at harvest is very important because when hydrolyzed by invertase it results in accumulation of reducing sugars making the potatoes unfit for processing (Uppal, 1999).

The non-reducing sugars increased continuously up to 45 days of storage and then decreased up to the last of experimental observation. The variety Kufri Pukhraj showed the highest non-reducing sugar and the variety Kufri Pushkar the lowest. It was observed that the larger potato tubers had higher sucrose content as compared to smaller tubers. The results are in conformity with the findings of Nowotny and Samotus (1965).

### Reducing sugars (mg/100 g)

Significant difference was recorded among the varieties, tuber sizes and their interactions for reducing sugars (Table 2).The data given in the Table indicate that the reducing sugars of tubers decreased up to 45th day of storage, but thereafter, it increased continuously up to the end of the experiment. The accumulation of reducing sugars after 45 days of storage could be attributed to the dormancy release and onset of sprouting

**Table 1: Effect of varieties and tuber size on non-reducing sugar (mg/100g) during storage under ambient conditions**

Treatments		Storage period (days)		
		0	45	90
Kufri Badshah (V <sub>1</sub> )	Small (S <sub>1</sub> )	144.0	188.0	130.0
	Medium (S <sub>2</sub> )	176.0	197.0	152.0
	Large (S <sub>3</sub> )	200.0	220.0	188.0
Mean V <sub>1</sub>		173.3	201.7	156.6
Kufri Bahar (V <sub>2</sub> )	Small (S <sub>1</sub> )	155.0	170.0	137.0
	Medium (S <sub>2</sub> )	176.0	190.0	166.0
	Large (S <sub>3</sub> )	185.0	211.0	181.3
Mean V <sub>2</sub>		172.0	190.4	161.4
Kufri Pukhraj (V <sub>3</sub> )	Small (S <sub>1</sub> )	150.0	173.0	152.0
	Medium (S <sub>2</sub> )	175.0	195.0	178.0
	Large (S <sub>3</sub> )	200.0	209.0	204.0
Mean V <sub>3</sub>		175.0	192.0	178.0
Kufri Pushkar (V <sub>4</sub> )	Small (S <sub>1</sub> )	122.0	135.7	116.0
	Medium (S <sub>2</sub> )	144.0	160.0	143.0
	Large (S <sub>3</sub> )	170.0	187.3	173.0
Mean V <sub>4</sub>		145.7	161.0	144.1
Mean of Size	Small (S <sub>1</sub> )	142.8	166.7	133.8
	Medium (S <sub>2</sub> )	168.0	185.5	159.8
	Large (S <sub>3</sub> )	188.8	206.9	186.7
C.D. 1% level of significance				
Variety		3.3	2.2	2.0
Size		2.8	1.9	1.8
Variety x Size		5.6	3.8	3.5

**Table 2: Effect of varieties and tuber size on reducing sugars (mg/100 g) during storage under ambient conditions**

Treatments		Storage period (days)		
		0	45	90
Kufri Badshah (V <sub>1</sub> )	Small (S <sub>1</sub> )	440.0	332.0	450.0
	Medium (S <sub>2</sub> )	376.0	285.0	392.0
	Large (S <sub>3</sub> )	315.0	230.0	332.0
Mean V <sub>1</sub>		377.0	282.3	391.3
Kufri Bahar (V <sub>2</sub> )	Small (S <sub>1</sub> )	350.0	260.0	365.0
	Medium (S <sub>2</sub> )	300.0	210.0	312.0
	Large (S <sub>3</sub> )	255.0	172.0	242.0
Mean V <sub>2</sub>		301.7	214.7	306.3
Kufri Pukhraj (V <sub>3</sub> )	Small (S <sub>1</sub> )	450.0	330.0	445.0
	Medium (S <sub>2</sub> )	385.0	270.0	362.0
	Large (S <sub>3</sub> )	310.0	221.3	312.0
Mean V <sub>3</sub>		381.7	273.8	373.0
Kufri Pushkar (V <sub>4</sub> )	Small (S <sub>1</sub> )	355.0	264.0	362.0
	Medium (S <sub>2</sub> )	295.0	200.0	300.0
	Large (S <sub>3</sub> )	230.0	150.0	242.3
Mean V <sub>4</sub>		293.3	204.7	301.4
Mean of Size	Small (S <sub>1</sub> )	398.8	296.5	405.5
	Medium (S <sub>2</sub> )	339.0	241.8	341.5
	Large (S <sub>3</sub> )	277.5	193.3	282.1
C.D. at 1% level of significance				
Variety		3.2	3.3	3.3
Size		2.8	2.9	2.8
Variety x Size		5.5	5.7	5.6

as the varieties showed sprouting, which continued to increase up to the end of storage. These results confirm the findings of Singh and Verma (1979) and Kumar *et al.* (2002). Pressey and Shaw (1996) also observed a decline in reducing sugars during storage at higher temperature. During storage, the maximum reducing sugars were obtained from the tubers of Kufri Pukhraj (381.7 mg), whereas, the minimum reducing sugars were obtained from the tubers of Kufri Pushkar (293.3 mg). Kufri Badshah (391.3 mg) showed the significantly maximum reducing sugars followed by Kufri Pukhraj (373.0 mg), whereas,

Kufri Pushkar showed the significantly minimum reducing sugars (301.4) followed by Kufri Bahar (306.3 mg) at the end of the experiment.

Potato tuber size and reducing sugars had the significantly negative correlation. Among the sizes, small sized tubers showed the significantly maximum value for reducing sugars (398.8, 296.5 and 405.5 mg), followed by medium sized tubers (339.0, 241.8 and 341.5 mg), whereas, large sized tubers showed the significantly minimum value for reducing sugars

**Table 3: Effect of variety and tuber size on total sugars (mg/100 g) during storage under ambient conditions**

Treatments		Storage period (days)		
		0	45	90
Kufri Badshah (V <sub>1</sub> )	Small (S <sub>1</sub> )	604.0	520.0	580.0
	Medium (S <sub>2</sub> )	552.0	482.0	544.0
	Large (S <sub>3</sub> )	515.0	450.0	520.0
Mean V <sub>1</sub>		557.0	484.0	548.0
Kufri Bahar (V <sub>2</sub> )	Small (S <sub>1</sub> )	505.0	432.0	499.3
	Medium (S <sub>2</sub> )	476.0	402.0	477.0
	Large (S <sub>3</sub> )	440.0	382.0	422.0
Mean V <sub>2</sub>		473.7	405.3	466.1
Kufri Pukhraj (V <sub>3</sub> )	Small (S <sub>1</sub> )	600.0	500.0	592.0
	Medium (S <sub>2</sub> )	560.0	465.0	540.0
	Large (S <sub>3</sub> )	510.0	430.0	515.3
Mean V <sub>3</sub>		556.7	465.0	549.1
Kufri Pushkar (V <sub>4</sub> )	Small (S <sub>1</sub> )	477.0	400.0	478.0
	Medium (S <sub>2</sub> )	440.0	370.0	444.0
	Large (S <sub>3</sub> )	400.0	336.3	414.0
Mean V <sub>4</sub>		438.3	368.8	445.3
Mean of Size	Small (S <sub>1</sub> )	546.0	463.0	537.3
	Medium (S <sub>2</sub> )	507.0	429.8	501.3
	Large (S <sub>3</sub> )	466.3	399.6	467.8
C.D. at 1% level of significance				
Variety		4.8	5.0	3.6
Size		4.2	4.3	3.1
Variety x Size		8.3	8.7	6.2

(277.5, 193.3 and 282.1 mg) at first, second and third observation taken on zero, 45th and 90th day of storage, respectively. The specific gravity, which was lower of smaller tubers than the medium and larger tubers, had a negative correlation with reducing sugars. These results are in accordance with the findings of Somorowska (1971). It was noticed that reducing sugars were higher in smaller tubers than the medium and larger ones. The results are in agreement with the findings of Nelson and Shaw (1976).

#### Total sugars (mg/100 g)

Significant difference was recorded in terms of total sugar among the varieties, tuber sizes and their interactions for reducing sugars (Table 3). Potato tuber sugar content may be effected by cultivar, maturity, production site, and season as well as storage temperature. Among the varieties, Kufri Badshah (557.0, 484.0 and 548.0 mg) had the maximum value for total sugars, whereas, Kufri Pushkar had the significantly minimum value for total sugars (438.3, 368.8 and 445.3 mg) at starting, mid and end of the experiment, respectively. At first and second observations, Kufri Badshah and Kufri Pukhraj were statistically at par with each other. Increase in total sugars or a particular sugar and dry matter is a heritable character, but is also affected by a number of environmental factors (Ezekiel *et al.*, 1999). Sugar level in potatoes during tuberization and at harvest is largely dependent on cultivar (Sinha *et al.*, 1992). Quantity and kind of sugars in particular cultivar are inherited characteristics (Lauer and Shaw, 1970).

The value of total sugars content firstly decreased significantly up to 45th day of storage, and thereafter, it significantly increased progressively up to the end of the experiment. Accumulation of total sugars, particularly after 45 days of storage, could be attributed to the dormancy release and onset of sprouting as thereafter the cultivars showed sprouting, which continued to increase up to the end of experiment.

Observations made in this experiment are similar to the findings of earlier workers (Singh and Verma, 1979; Kumar *et al.*, 2002).

There was a significantly negative correlation between potato tuber size and total sugars. The value for total sugars was significantly highest in small sized tubers (546.0, 463.0 and 537.3 mg) followed by medium sized tubers (507.0, 429.8 and 501.3 mg) and it was lowest in large sized tubers (466.3, 399.6 and 467.8 mg) on zero, 45th and 90th day of the experiment, respectively. The change in sugar content during storage consequently increased the ratio of reducing sugars to non-reducing sugar. It was recorded that the content of total sugars in potato had dependency on tuber size. The results confirm the findings of Nowotny and Samotus (1965). Results from the present study reveal that the total sugars were higher in smaller tubers than in larger ones since the total sugars decreased when the potato tubers reached full maturity.

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