Research Article

Biochemical Behaviour of Potato Tubers during Storage

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Abstract

The study was planned to assess the status of sugar and starch content of two harvests in relation with seed storage. The present investigation was carried out with potato cultivar Kufri Himalini. *In-vitro* developed plantlets were transplanted in field and tubers were harvested twice at monthly intervals i.e. July (90 DAP) and August (120 DAP). Potato tubers were stored for 120 days at ambient condition. Estimation of starch and reducing sugar were carried out at monthly intervals. Results found that both the harvest showed significant difference in starch content between different grades and storage time. The maximum starch content was recorded with larger size S_1 (19.49%), medium size S_1 (19.41%) harvest of 120 DAP and minimum value was recorded with small sized tubers S_5 (13.84%) harvest of 90 DAP. Among two harvests, tubers of 90 DAP had no significant difference in total reducing sugar content between different grades and storage time whereas tubers of 120 DAP showed significant difference. The maximum value for reducing sugar was recorded with small size S_5 (0.63%) followed by medium size tubers S_5 (0.62%) harvest of 90 DAP.

Quality of potato seed tubers depends on the sugar and starch content, which is depends on their maturity level. Early harvest i.e., 90 DAP showed higher starch conversion which was responsible for higher reducing sugar by which sprouting might be enhanced. So we can use early harvest, which reduces the storage time and also vigorous seed tubers will be available earlier for next planting season.

Keywords: potato, reducing sugar, starch, storage

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Introduction

Potato (*Solanum tuberosum* L.) is the *king of vegetables* also known as white or Irish potato, belongs to family Solanaceae. The edible part of potato is botanically known as underground-modified stem. It is commonly grown for starchy tubers. Indian vegetable basket is incomplete without potato. Its dry matter, edible energy and edible protein make it nutritionally superior vegetable as well as staple food not only in our country but also throughout the world. It is the fourth largest crop in terms of fresh produce after rice, wheat and maize [8] Increase in production often resulting in glut has also led to several post harvest problems including that of storage. Unlike in temperate regions, in India the potato is harvested in the beginning of summer. Its price is low at harvest, increases rapidly in April-May and are almost double in July-August [3].

Potatoes being a living organism require an effective management for storage. The storage life of potato and its quality of potato during storage is lowered mainly by the processes like respiration, sprouting, evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tuber and damage by extreme temperatures. All these losses depend on the storage conditions and therefore can be restricted, by maintaining favourable conditions in the store. However, the storability of potatoes is already determined before the beginning of storage, by such factors as cultivar, growing techniques, type of soil, weather conditions during growth, diseases before harvesting, and maturity of potatoes at the time of harvesting, damage to tubers during lifting, transport and filling of the store [1]. Maintenance of high quality of potatoes for longer storage is very difficult. Biochemical conversions (starch to sugar and simultaneously sugar to starch) in potato during tuberization and storage are responsible for these losses [4]. During storage, starch to sugar conversion is one-third lower, whereas, the rate of opposite reaction, *i.e.*, sugar to starch, is twenty times less as compared to reaction rate during tuberization but the sugar oxidation rate during respiration is decreased by three times. As a result of above conversions, there is accumulation of reducing sugars in potato during storage, which make the potato sweetening. Therefore, special demands have to be met for a good storage in order to limit losses as much as possible. Storage temperature and humidity of the atmosphere play an important role in keeping the losses low and maintaining the quality of stored potatoes. Even when storage of potato is done under perfect 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 potato variety, maturity of the tubers at harvesting, storage conditions and storage duration. Keeping in view the above facts, the present experiment entitled, biochemical behaviour of potato tubers during storage was planned to assess the effect of harvest time on potato seed quality.

Material and Methods

The present investigation was carried out with potato cultivar Kufri Himalini during the year 2011 at department of seed science & technology, College of Forestry and Hill Agriculture Hill Campus, Ranichauri, District Tehri Garhwal (Uttarakhand). *In-vitro* developed potato plantlets were transplanted in field in 2nd fortnight of April and all the recommended agronomic practices were followed during experiment. Tubers were harvested twice at monthly intervals i.e. July (90 DAP) and August (120 DAP). During 1st harvest, apical tubers either small or big were plucked and in the 2nd harvest all tubers were plucked. The harvested tubers were divided into small, medium, and large size based on weight specified as G_1< 5.00, G_2 5.00-24.99, G_3 25-45.00g. Harvested tubers were stored for 120 days at ambient condition. Estimation of starch and reducing sugar were carried out at monthly intervals viz., 0days (S_1), 30days (S_2), 60days (S_3), 90days (S_4) and 120days (S_5). Starch was estimated during storage by Anthrone Reagent Method and reducing sugar was estimated by Nelson-Somogyi method [13]. Experiment was analysed statistically in factorial arrangement with complete randomize block design (CRD) with three replicates.

Result and Discussion

Estimation of Starch

In general starch content declined under all storage temperatures. The perusal of data pertaining to starch content of tubers (**Table 1**) estimated in monthly interval reveals that the starch content decreased with the progress in storage period. It might be due to the hydrolysis of starch by starch degrading enzymes. Similar finding were reported by [10, 2]. Decrease in starch content during storage was due to its conversion into sugar and similar observation was also recorded by [15]. Starch was lower after storage at temperature of 4 or 8°C and increased after storage at higher temperature [6]. Decline of starch content during storage at 10°C due to conversion of starch into sugar in potato cultivar Danshaku was also reported by [23].

Table 1 Starch content (%) of tubers harvested 90 and 120 DAP

Storage time (S)	Grade (G)							
	Harvest of 90 DAP				Harvest of 120 DAP			
	Small	Medium	Large	Mean	Small	Medium	Large	Mean
S_1	18.733	18.827	18.923	18.828	19.317	19.417	19.497	19.410
S_2	17.733	17.803	17.877	17.804	18.150	18.220	18.357	18.242
S_3	16.093	16.233	16.373	16.233	17.210	17.297	17.443	17.317
S_4	14.437	14.603	14.743	14.594	15.093	15.207	15.320	15.207
S_5	13.840	13.950	14.030	13.940	14.073	14.127	14.180	14.127
Mean	16.167	16.283	16.389		16.769	16.853	16.959	
	S	G	S X G		S	G	S x G	
SEm±	0.009	0.007	0.016		0.007	0.006	0.012	
CD	0.026	0.020	0.045		0.021	0.016	0.036	

*DAP- Days after planting

On the basis of estimation made at monthly interval during storage, all grade tubers showed significant difference with two harvests (Table 1). Among harvest of 90 DAP, S_1 tubers showed higher starch content (18.9%) with larger tubers likewise similar trend was observed among harvest of 120 DAP with larger tubers of 19.49% starch content in S_1.

With the increase of storage duration the starch content declined and reducing sugar content increased in all the grades. This observation was in accordance to the physiological process explained by [11] that the accumulation of starch at the time of harvest was at its highest level. The authors further explained that potato being an underground stem, the photosynthate-largely sucrose- was translocated into the developing tubers and stored as starch; some sucrose was also used for respiration. Since this was a reversible process starch could also be converted back into sucrose. Starch content was always higher in larger tubers as compared to smaller one. There was a positive correlation between potato tuber size and starch content in both the harvest. With respect to starch content, the tuber sizes showed significant difference among them. Quality of seed potato depends on the starch content, which is

related to sprouting vigour. [21] reported that sprouting rates of larger micro-tubers sprouted significantly earlier while the small tubers sprouted very late. The sprout length was significant in large tubers, while medium tubers were on par with small tubers. Starch was converted to sucrose, glucose and fructose, the levels of which depended on their maturity. These sugars are used as energy source for the sprouting of seed potatoes. Superior sprouting was associated with high initial carbohydrate content, combined with a higher rate of disappearance of starch and reducing sugar during sprouting.

Under present experiment the interaction effect between harvest time and size differed significantly during storage. Both the harvest tubers (90 and 120 DAP) found significant difference in starch content between different grades and storage time. The maximum value for starch was recorded with larger size S_1 (19.49%), followed by medium size S_1 tubers (19.41%) harvest of 120 DAP whereas, the minimum value for starch was recorded with small size S_5 tubers (13.84%) harvest of 90 DAP. This result suggested that the ambient conditions did not affect starch content at greater extent in either of the two differently harvested batches with different grades.

Estimation of Reducing Sugar

Observations recorded for reducing sugar during storage were showed in **Table 2**. The reducing sugar content of the potato is affected by several factors, including variety, growing conditions, maturity at harvest, post harvest handling stress and the storage environment [18]. In the present study the values were recorded at monthly intervals and found that reducing sugar was present in relatively small amount in S_1 tubers and its concentration was increased throughout the storage period. This increase was due to the conversion of starch and sucrose into reducing sugar by the enzyme action [18, 10, 7]. During storage starch degradation occurs primarily through the action of starch phosphorylase and eventually reducing sugars accumulate through various enzymatic reactions [16]. The content of reducing sugar in present study gradually increased with time of storage. Similar observation was reported by [22] that fresh tubers available from July to December month had low reducing sugar content. Further, when tubers were stored at low temperature the level of reducing sugar had increased. [19] also reported that freshly harvested tubers of Indian potato cultivars Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Jyoti, Kufri Lalima, Kufri Sherpa and Kufri Sindhuri showed an increased in reducing sugar during storage and significant correlation between reducing sugar content and basal and total invertase activity as this enzyme hydrolysed sucrose to reducing sugars. [5] reported that reducing sugars increased during storage and out of the seven varieties grown at Modipuram, only Kufri Chipsona 1 showed lower reducing sugars. The reducing sugars were present in relatively small amount in freshly harvested tubers were, further reported to gradually increase at 42F° during storage. Potato storage in ordinary rooms, traditional heaps, *etc*. at relatively higher temperature (25-30ºC) showed very little increase in reducing sugars [19].

Table 2 Reducing sugar content (%) of tubers harvested 90 and 120 DAP

Storage time (S)	**Grade (G)**							
	Harvest of 90 DAP				**Harvest of 120 DAP**			
	S	**M**	**L**	**Mean**	**S**	**M**	**L**	**Mean**
S1	0.337	0.320	0.310	0.322	0.303	0.270	0.250	0.274
S2	0.410	0.390	0.377	0.392	0.367	0.360	0.347	0.358
S3	0.477	0.463	0.453	0.464	0.437	0.430	0.420	0.429
S4	0.553	0.543	0.527	0.541	0.513	0.503	0.493	0.503
S5	0.630	0.623	0.610	0.621	0.587	0.580	0.573	0.580
Mean	0.481	0.468	0.455		0.441	0.429	0.417	
	S	G	S x G		S	G	S x G	
SEm±	0.003	0.002	0.004		0.002	0.001	0.003	
CD	0.007	0.006	N/A		0.005	0.004	0.009	

*DAP- Days after planting

Reducing sugar of potato also showed statistically significant variation for different time of harvest. In present study tubers harvested at 120 DAP had significantly less reducing sugars as compared to 90 DAP as it explain the reason of immature tubers have higher content of reducing sugars than fully matured tubers [20]. The reduction in sugar content between harvest of 90 and 120 DAP was due to conversion of reducing sugar to starch as tubers matured [9]. It is therefore beneficial to harvest at full maturity to obtain tubers with required sugar levels. [14] reported that when mature tubers were stored at relatively high temperature, the concentration of reducing sugars remained low. The freshly harvested mature tubers of some Indian potato cultivars contain low level of reducing sugars [12].

Increase in reducing sugar content was recorded in all grade tubers during storage. Potato tuber size and reducing sugars had the significant negative correlation. Among the sizes, small sized tubers showed the significantly maximum value for reducing sugars as compared to medium and large sized tubers. A mature potato had a lower content of reducing sugars [17].

Under present investigation the interaction effect between harvest time and size differed significantly during storage. Among two harvests, 90 DAP had no significant difference in total reducing sugar content between different grades and storage time whereas tubers of 120 DAP showed significant difference. This outcome suggested that the ambient air conditions did not trigger much sugar accumulation or reduction in either of the two differently harvested batches, and could therefore be appropriate for long term storage. The maximum value for reducing sugar was recorded with small size S_5 tubers (0.63%) followed by medium size S_5 tubers (0.62%) harvest of 90 DAP whereas, the minimum value for reducing sugars was recorded with large size S_1 tubers (0.25%) harvest of 120 DAP.

Conclusion

Quality of potato seed tubers depends on the sugar and starch content which is related to sprouting vigour. Conversion of starch depends on their maturity level. Early harvest i.e., 90 DAP showed higher starch conversion which was responsible for higher reducing sugar by which sprouting might be enhanced. So we can use early harvest instead of 120 DAP which reduces the storage time and also vigorous seed tubers will be available earlier for next planting season.

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