Research Article

Biochemical Behavior of Potato Tubers during Storage as Affected by Different Nitrogen Levels

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Abstract

The objective of this experiment was to analyse the effect of different nitrogen levels on biochemical property of potato tubers. The experiment was carried out at the post-harvest laboratory of the department of vegetable science, CCS Haryana Agricultural University, Hisar during the *rabi* season of 2019-20. Four different doses of nitrogen (0, 80, 160, and 240 kg ha^{-1}) and three different potato cultivars *viz*., 'Kufri Pukhraj', 'Kufri Gaurav' and 'AICRP-P-39' were used in different combinations. The harvested potatoes were stored in the laboratory for three months using a complete randomized design to study their biochemical behavior. Results revealed a positive relationship between nitrogen content and ascorbic acid in tubers up to a certain extent only. Whereas, different sugars level in tubers showed inconsistent behavior with varying nitrogen doses. The cv. 'Kufri Pukhraj' found superior to other tested cultivars for maintaining their biochemical quality during storage.

Keywords: Cultivar, nitrogen, potato, ascorbic acid, sugars, tubers

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Introduction

Potato (*Solanum tuberosum*) is the third most significant food crop in the world, after wheat and rice, and is grown in over 150 countries [1]. India is one of the leading potato producing country in the world with a production of 50.19 million MT tubers over an area of 2.17 million hectares and an average productivity of 23.1 MT ha^{-1} [2]. Potatoes are important in both human nutrition and the food processing industry [3]. The crop can be grown in almost every state and under a variety of conditions. Potato availability per capita in India is 17.7 kg, which is about a third of the global average. The potato is a high-valued vegetable crop in Haryana and is renowned as the "King of Vegetables." It is mostly grown in the Haryana districts of Ambala, Panchkula, Yamunanagar, Kurukshetra, Hisar, and Karnal. Because of its extended vegetative growth stage, the potato plant absorbs nutrients from both organic and inorganic fertilisers quite efficiently [4]. In potato tubers, different fertiliser formulations, rates, and combinations can increase or reduce dry matter, starch, protein, and sugar content [5]. Aside from providing energy and high-quality protein, potatoes have been shown to be a good source of vitamins and minerals, as well as a good source of Vitamin C, also known as ascorbic acid. Among the numerous key nutrients, nitrogen is the most important and limiting nutrient for potato crop growth and development. Nucleic acids, proteins, free amino acids, and enzymes all have a function in the structure and configuration of nucleic acids, proteins, and enzymes in plants. During the growth phase, weather variables, physiological age of the seed tuber, cultivated variety, and soil type, as well as agronomic factors such as leaf withering before maturity and harvest date, influence the biochemical composition of stored tubers [6]. Potato postharvest handling is difficult due to its perishable nature, and tuber quality losses after harvest are a big problem that decreases farmers' income. For smallholder growers, refrigerated storage is too expensive [7]. Therefore, farmers must retain the crop's quality until it is sold or consumed in sub-optimal traditional storage conditions. However, in this situation, tuber quality deteriorates quickly, and post-harvest losses are high. As a result, better ventilation and other factors that prevent tuber quality degradation should be maintained. The biochemical parameters such as ascorbic acid and sugars content are prone to losses during storage in tubers and affect the edible quality of tubers as such. The more accumulation of sugars is not desirable in tubers in domestic households. Also, high ascorbic acid is preferred in tubers by consumers. There is a scarcity of information on the effect of applying nutrients and their optimum dose on biochemical attributes and quality of potato tubers in our country. Developing suitable nutrition management strategies is essential for increasing productivity and improving the quality of potato tubers. Keeping in mind the above stated facts, the present study was conducted to evaluate the changes in ascorbic acid and sugars content of potato tubers of different cultivars as affected by different nitrogen levels during storage.

Materials and Methods

This study was carried out at Post-harvest laboratory of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar (29°09'N and 75°43'E, elevation 215 m) during the *rabi* season of 2019-20. The soil of the experimental site was sandy loam with approximately 0.48 organic carbon and pH 7.6. The treatments comprised of three potato cultivars *viz*., 'Kufri Pukhraj', 'Kufri Gaurav' and 'AICRP-P-39' and four doses of nitrogen (0, 80, 160 and 240 kg ha^{-1}). The experiment included three replications and was set up in a completely randomised design (factorial). On the 23rd of October, 2019, the crop was planted. All of the suggested package of practices were implemented uniformly in accordance with the crop's needs, including irrigation. At 35 DAP, nitrogen was applied in the form of urea fertiliser (**Figure 1**). On February 21, 2020, potato tubers were physically dug. Following that, on March 5, 2019, three kg of healthy, clean tubers from each treatment were stored in the post-harvest laboratory for three months. Different parameters were estimated during and after the storage such as ascorbic acid (mg/100g), reducing sugars (mg/100g), non-reducing sugars (mg/100g) and total sugars (mg/100g). The reducing sugars (mg/100g), non-reducing sugars (mg/100g), total sugars (mg/100 g) and ascorbic acid (mg/100 g) in tubers were calculated from each replication at the start, mid and end of the experiment. Reducing sugars were estimated by using method of [8], while the total sugars were estimated by using the method of [9]. The content of non-reducing sugars was obtained by subtracting the values of reducing sugars from that of total sugars and multiplying the value with 0.95 [10]. Statistical analysis of recorded data was carried out with the help of OPSTAT software package.

Figure 1. Field view of potato crop after nitrogen treatment.

Results and Discussion

Ascorbic acid in tubers (mg/100g)

A decreasing trend in ascorbic acid content in potato tubers was observed during storage (**Table 1**), which could be attributed to enzymatic loss of L-ascorbic acid where it get converted to 2-3-dioxy-L-gluconic acid [11]. The results are in agreement with the findings of [12], [13] and [14]. The nitrogen treatments differed significantly with respect to ascorbic acid in tubers during storage period. Application of nitrogen at the rate of 160 kg ha^{-1} resulted in significantly highest ascorbic acid content (28.20, 23.03 and 16.25 mg) in potato tubers, followed by application of 240 kg N/ha (26.70, 21.28 and 14.96 mg), while lowest ascorbic acid content (19.45, 15.97 and 11.21 mg) in potato tubers was obtained under control at 0^{th}, 45^{th} and 90^{th} day of storage period, respectively. It might be due to positive effect of nitrogen application on nutrient uptake by tubers, which could have promoted ascorbic acid in tubers. Similar results were found by [15] and [16] in potato. Significant difference in ascorbic acid content of tubers due to potato cultivars was also noted, which might be the characteristic of genetic variability as supported by [14]. Significantly highest ascorbic acid content was obtained from the tubers of cv. 'Kufri Pukhraj' (26.14, 21.58 and 15.17 mg), followed by 'AICRP-P-39' (24.07, 19.15 and 13.76 mg), while, lowest content of ascorbic acid (22.88, 18.35 and 12.88 mg) was recorded from the tubers of cv. 'Kufri Gaurav' at 0^{th}, 45^{th} and 90^{th} day of storage period, respectively. The interaction effects between nitrogen doses and cultivars differed significantly for all the treatment combinations.

Table 1 Effect of nitrogen doses on ascorbic acid, non-reducing sugar, reducing sugar and total sugar (mg/100g) in tubers of different potato cultivars during storage under ambient conditions

N doses (kg/ ha)	Cultivars	Ascorbic acid (mg/100g)			Non-reducing sugar (mg/100g)			Reducing sugar (mg/100g)			Total sugar (mg/100g)		
		Storage period (days)											
		0	**45**	**90**	**0**	**45**	**90**	**0**	**45**	**90**	**0**	**45**	**90**
0	K. Pukhraj (V_1)	20.46	16.87	11.70	206.2	227.8	213.5	407.0	346.2	383.1	613.2	574.0	596.6
(N_0)	K. Gaurav (V_2)	18.12	14.95	10.55	208.2	230.4	220.1	414.5	359.8	394.0	622.7	590.2	614.1
	AICRP-P-39 (V_3)	19.77	16.08	11.38	199.3	228.1	224.8	398.2	342.5	377.6	597.5	570.6	602.4
Mean of N_0		**19.45**	**15.97**	**11.21**	**204.6**	**228.8**	**219.5**	**406.6**	**349.5**	**384.9**	**611.1**	**578.3**	**604.4**
80	K. Pukhraj (V_1)	24.44	20.24	14.23	212.2	211.4	216.5	424.4	378.5	396.6	636.6	589.9	613.1
(N_1)	K. Gaurav (V_2)	21.78	17.41	12.48	208.2	219.2	208.1	435.0	381.2	415.9	643.2	600.4	624.0
	AICRP-P-39 (V_3)	23.11	17.81	13.23	214.0	229.1	230.6	404.5	361.4	380.4	618.5	590.5	611.0
Mean of N_1		**23.11**	**18.49**	**13.31**	**211.5**	**219.9**	**218.4**	**421.3**	**373.7**	**397.6**	**632.8**	**593.6**	**616.0**
160	K. Pukhraj (V_1)	30.12	25.62	18.30	200.5	209.7	214.1	445.7	393.8	418.2	646.2	603.5	632.3
(N_2)	K. Gaurav (V_2)	26.95	21.32	14.69	193.1	204.0	202.9	460.3	414.0	436.9	653.4	618.0	639.8
	AICRP-P-39 (V_3)	27.54	22.15	15.75	200.7	201.1	192.7	430.0	398.2	422.5	630.7	599.3	615.2
Mean of N_2		**28.20**	**23.03**	**16.25**	**198.1**	**204.9**	**203.2**	**445.3**	**402.0**	**425.9**	**643.4**	**606.9**	**629.1**
240	K. Pukhraj (V_1)	29.56	23.59	16.45	201.6	232.0	217.9	470.7	425.4	450.6	672.3	657.4	668.5
(N_3)	K. Gaurav (V_2)	24.68	19.71	13.78	199.0	236.2	230.5	485.5	430.0	458.1	684.5	666.2	688.6
	AICRP-P-39 (V_3)	25.87	20.55	14.66	215.5	237.9	219.5	453.0	406.2	440.5	668.5	644.1	660.0
Mean of N_3		**26.70**	**21.28**	**14.96**	**205.4**	**235.4**	**222.6**	**469.7**	**420.5**	**449.7**	**675.1**	**655.9**	**672.4**
Mean	K. Pukhraj (V_1)	*26.14*	*21.58*	*15.17*	*205.1*	*220.2*	*215.5*	*437.0*	*386.0*	*412.1*	*642.1*	*606.2*	*627.6*
of	K. Gaurav (V_2)	*22.88*	*18.35*	*12.88*	*202.1*	*222.5*	*215.4*	*448.8*	*396.3*	*426.2*	*651.0*	*618.7*	*641.6*
Culti var	AICRP-P-39 (V_3)	*24.07*	*19.15*	*13.76*	*207.4*	*224.1*	*216.9*	*421.4*	*377.1*	*405.3*	*628.8*	*601.1*	*622.2*
C.D. at 1% level of significance													
Nitrogen		0.55	0.47	0.34	4.8	5.3	5.1	9.7	7.1	9.0	18.2	15.3	17.6
Cultivar		0.48	0.39	0.30	2.2	3.1	2.8	7.6	5.6	6.9	14.9	11.2	12.8
Nitrogen × Cultivar		0.96	0.79	0.59	7.3	9.2	8.5	17.1	14.2	15.8	27.5	24.6	25.0

Non-reducing sugars (mg/100g)

The non-reducing sugars in tubers increased continuously up to 45 days of storage and then decreased afterwards up to the end of experiment (Table 1). No continuous trend was observed for sucrose content in tubers with increase in nitrogen application. Significant variation was noticed among potato cultivars for non-reducing sugars. The cv. 'AICRP-P-39' showed the highest non-reducing sugars and the cv. 'Kufri Gaurav' the lowest, during the start and end of the storage study. Similar findings were recorded by [17] and [18].

Reducing sugars (mg/100g)

The reducing sugars of potato tubers decreased up to 45 days of storage, and thereafter, it increased continuously up to the last of the experimental observation (Table 1). The accumulation of reducing sugars after 45 days of storage might be due to the dormancy break and initiation of sprouting, which continued to increase up to the end of storage study. These results are in line with the findings of [19] and [20]. The reducing sugars in potato tubers differed significantly, depending on nitrogen dose and cultivar. Soluble sugars in tubers increased with increasing nitrogen doses, *i.e.*, the highest content of reducing sugars was observed with the N application of 240 kg ha^{-1}, followed by 160 kg ha^{-1}, whereas minimum was observed under control. Similar results were found by [21], [22] and [23]. Significant variation in reducing sugars content was observed among the cultivars, being maximum with the cv. 'Kufri Gaurav' and minimum with 'AICRP-P-39'. The findings are in line with [24].

Total Sugars (mg/100g)

The total sugars of potato tubers decreased up to 45 days of storage, and thereafter, it increased continuously up to the last of the experiment (Table 1). Accumulation of total sugars, particularly after 45 days of storage, might be attributed to the dormancy release and onset of sprouting, which continued to increase up to the end of experiment. These results are similar to the findings of [19, 20]. Total sugars in potato tubers differed greatly, depending on nitrogen dose, cultivar and storage period. The variation in total sugars content during storage consequently increased the ratio of reducing sugars to non-reducing sugar. Total sugars in tubers increased with increasing nitrogen doses, *i.e.*, the highest sugars content was observed with the N application of 240 kg ha^{-1}, followed by 160 kg ha^{-1}, whereas

minimum was observed under control. Similar results were found by [22, 23]. Significant variation in total sugars content was observed among the cultivars, being maximum with the cv. 'Kufri Gaurav' and minimum with 'AICRP-P-39'. The findings are in line with [18] Significant interaction effect of nitrogen and cultivar was observed for total sugars content in potato tubers, which was supported by [25].

Conclusion

Different quality parameters of tubers like ascorbic acid, reducing sugars, non-reducing sugars, and total sugars behaved inconsistent to different nitrogen doses. Some quality traits improved as nitrogen doses increased, whereas others deteriorated. Ascorbic acid increased upto N levels of 160 kg/ha, thereafter decreased. Non-reducing sugars keep on decreasing, on enhancing the nitrogen levels up to 160 kg/ha, thereafter it increased, which is an undesirable trait. The amount of reducing sugars and total sugars showed a direct proportional relation with nitrogen levels. Also, among the cultivars, tubers of the cv. 'Kufri Pukhraj' were better in quality than 'Kufri Gaurav' and 'AICRP-P-39' after 90 days of storage. Based on the results, it is concluded that potato tubers of the cv. 'Kufri Pukhraj' supplied with 160 kg N/ha were superior in their biochemical quality traits.

Acknowledgements

We thank the Chaudhary Charan Singh Haryana Agricultural University, Hisar for their financial support.

References

[1] H. P. Singh. Policies and strategies conducive to Potato development in Asia and the Pacific region. In: Proceedings of the Workshop to Commemorate the International Year of Potato, 2008, p18-29.
[2] N.H.B. National Horticulture Board. Ministry of Agriculture and Farmers' Welfare, Government of India, 2018.
[3] K. Zaheer, M.H. Akhtar. Potato production, usage and nutrition-a review. Critical reviews in food science and nutrition, 2016, 56(5): 711-721.
[4] P. Harris. The Potato Crops: The scientific basis for improvement. Chapman and Hall, 1992.
[5] A. Makaraviciutte. Effects of organic and mineral fertilizers on the yield and quality of deferent potato varieties. Agronomy Research, 2003, 1(2):197-209.
[6] D. Vreugdenhil (ed.), Potato Biology and Biotechnology: Advances and Perspectives, Agronomic Practices, D.M. Firman, E.J. Allen, Elsevier, 2007, p169-178.
[7] G.M. Wolde Giorgis, G. Endale, B. Lemaga (ed.), Root and tuber crops: The untapped resources, Post-Harvest Management, E. Gebre, W. Gebremedhin, K. Bekele, B. Lemaga, 2008, p113-130.
[8] M.J. Somogyi. A new reagent for the determination of sugar. Journal of Biology and Chemistry, 1945, 160: 61-69.
[9] E.W. Yemm, A.J. Willis. The estimation of carbohydrates in plant extracts by anthrone. Journal of Biochemistry, 1954, 57: 508-514.
[10] M.J. Somogyi. Notes on sugar determination. Journal of Biology and Chemistry, 1952, 200:245.
[11] A.C. Hulme (ed.), The biochemistry of fruits and their products, Vol. I, Vitamin in fruits, L.W. Mapson, Academic press, New York, 1970, p369-386.
[12] K. Kameyama, H. Ito. Twenty-six years of commercialization on potato irradiation at Shihoro, Japan. Radiation Physics and Chemistry, 2000, 57: 227-230.
[13] J. Nouri, F. Toofanian. Extension of storage of onions and potatoes by gamma irradiation. Pakistan Journal of Biological Sciences, 2001, 4(10): 1275-1278.
[14] A. Brar. Storage studies in potato (Solanum tuberosum) under ambient conditions. M.Sc. Dissertation, CCS Haryana Agricultural University, Hisar, 2013.
[15] U. Bashir, F. Qureshi. Effect of nitrogen and farmyard manure on yield, nutrient content and quality of potato (Solanum tuberosum L.). International Journal of Biology and Life Sciences, 2014, 2(3): 786-791.
[16] B.N. Kumar, G. Padmaja, P.C. Rao. Effect of Different Levels of Nitrogen and Potassium on Ascorbic Acid, Crude protein and Crude fibre content of Okra (Abelmoschus esculentus L.). International Journal of Pure and Applied Bioscience, 2017, 5(4): 882-886.
[17] D. Kumar, R. Ezekiel, B.P. Singh. Post-harvest and pre-holding changes in sugar content of potatoes. Potato Journal, 2003, 30(1-2): 191-192.
[18] R. Kaur, D.S. Khurana. Growth, yield and quality of different processing cultivars of potato (Solanum tubersoum L.). International Journal of Pure and Applied Bioscience, 2017, 5(6): 594-599.

[19] M. Singh, S.C. Verma. Post-harvest technology and utilization of potato. In: Proceedings of the International Symposium of Post-harvest Technology and Utilization of Potato, CPRI, Shimla and CIP, New Delhi, 1979.
[20] D. Kumar, J. Singh, S.V. Singh. Changes in the sugars and dry matter content in tubers of some Indian potato cultivars and exotic hybrids stored at high temperature. Potato, Global Research and Development: Proceedings of the Global Conference on Potato, New Delhi, 2002, p1096-1100.
[21] M.A.S. Kandi, A. Tobeh, A. Gholipoor, S. Jahanbakhsh, D. Hassanpanah, O. Sofalian. Effects of different N fertilizer rate on starch percentage, soluble sugar, dry matter, yield and yield components of potato cultivars. Australian Journal of Basic and Applied Sciences, 2011, 5(9): 1846-1851.
[22] E. El-Hadidi, M. Ewais, A. Shehata. Fertilization effects on potato yield and quality. Journal of Soil Sciences and Agricultural Engineering, 2017, 8(12): 769-778.
[23] M. Pushpalatha, P.H. Vaidya, P.B. Adsul. Effect of graded levels of nitrogen and potassium on yield and quality of sweet potato (Ipomea batatas L.). International Journal of Current Microbiology and Applied Sciences, 2017, 6(5): 1689-1696.
[24] D. Kumar, R. Ezekiel. Developmental changes in sugars and dry matter content of potato tuber under sub-tropical climates. Scientific Horticulture, 2006, 110(2): 129-134.
[25] A.S. Jatav, S.S. Kushwah, I.S. Naruka. Performance of potato varieties for growth, yield, quality and economics under different levels of nitrogen. Advances in Research, 2017, 9(6): 1-9.

Publication History
Received 12.03.2022
Revised 13.05.2022
Accepted 15.05.2022
Online 31.05.2022