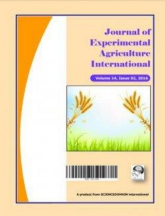

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Vitamin C, Antioxidant and Polyphenol Activity of Some Selected Potato Varieties as Influenced by Vermicompost

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Authors' contributions

This work was carried out in collaboration among all authors. Authors JF and TSR designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors RC, BCK and HKMD managed the analyses of the study. Author MM managed the literature searches and reviewed the final draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The application of vermicompost may improve the quality of potato. The present study revealed that vermicompost had a significant effect on most of the quality contributing parameters studied under the experiment. Results demonstrated that quality parameters increased with increasing vermicompost level. Among the sixteen treatments combination, BARI Alu-25 (Asterix) with vermicompost at the rate of 6 t/ha showed the highest ascorbic acid (Vitamin C), antioxidant and polyphenol content. In the case of ambient storage condition; ascorbic acid and polyphenol

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decreased with an increasing storing period while antioxidant content increased with the increasing storing period up to 60 days after storage (DAS). BARI Alu-25 (Asterix) and BARI Alu-29 (Courage) may store under ambient storage condition up to 60 DAS without imparting any significant quality losses just prior to the sprouting of the tuber. It may be concluded that the potato growers of Bangladesh may apply vermicompost on their field at the rate of 6 t/ha for maintaining the good quality of potato.

Keywords: Antioxidant; potato; polyphenol; vermicompost; vitamin C.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) belonging to the Solanaceae family is grown in nearly 150 countries and is the world's single major tuberous crop with a vital role in the global food system and food security [1]. It is the 4th world's largest produced crop after maize, wheat and rice. The total world potato production was estimated 376.83 million metric tons in 2016 [2]. It is the most highly produced non-grain staple crop in the world, with one-third of total production harvested in densely-populated developing countries, like China and India [3]. In the world top ten potato producing countries, Bangladesh ranks 7th position [4]. Nutritive value of potato is relatively high, because of protein content and composition of high percentage of essential amino acids: lysine, leucine, phenylalanine, threonine and valine [5]. Potato is also characterized by high amounts of starch and lower content of sugars. It is an excellent source of vitamin C and other biologically active substances, such as polyphenols and flavonoids, which are commonly described as antioxidants [6, 7]. These substances have a beneficial influence on the human being, as they protect against cardiovascular disease and cancer, as well as reduce blood cholesterol level. Ascorbic acid (L-AA, vitamin C) as an additive is largely accepted in human diets because of its antioxidative potential [8]. Potato peel is a good source of natural antioxidants. Its extract provides protection against acute liver injury [9] and oxidative damage to erythrocytes [10]. Due to the increasing demand of consumers and foreign importers on this important crop, special attention should be given to increase its quality. Now-a-days gradual deficiencies in soil organic matter and reduced yield of crop and quality are alarming problem in Bangladesh. The cost of inorganic fertilizers is very high. On the other hand, the organic manure is easily available to the farmers and its cost is low compared to that of inorganic fertilizers. Vermicompost is a good source of different macro and micronutrients particularly NPKS. The increased microbial activity also improves the availability of soil phosphorous and nitrogen, which is very helpful for increasing potato quality [4]. So, using different amount of vermicompost materials may put contribution for improving quality of potato in Bangladesh condition.

2. MATERIALS AND METHODS

The field experiment was conducted at the Agronomy research field at Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November 1, 2016, to April 30, 2017, in Rabi season. The experimental area was situated at the $23^0$77'N latitude and $90^0$33'E longitude at an altitude of 8.6 meters above the sea level [4]. Topsoil was silty clay in texture, olive-grey with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land. The experiment was provoked in a split-plot design with 3 replications. The variety was assigned to the main plot and vermicompost to subplot. The distance between row to row was 50 cm and plant to plant distance was 25 cm. The distance between plot to the plot was 75 cm. The size of the unit plot was 2 m x 2.5 m. The experiment consisted of two factors, were as follows: Factor A: Potato Varieties (V-4); V_1: BARI TPS-1, V_2: BARI Alu-28 (Lady Rosetta), V_3: BARI Alu-25 (Asterix), V_4: BARI Alu-29 (Courage). Factor B: Vermicompost level (M-4); M_1: 0 t/ha (Control), M_2: 2 t/ha, M_3: 4 t/ha, M_4: 6 t/ha. All varieties of seed potato (certified seed) were collected from Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and from BARI sub-station. Individual weight of seed potato was 60-70 g. Collected seed tubers were kept in room temperature to facilitate sprouting. Finally, sprouted potato tubers were used as planting material. Recommended doses of fertilizer were used as Urea 250 kg/ha, TSP 150 kg/ha, MoP 250 kg/ha, Gypsum 120 kg/ha,

Zinc Sulphate 10 kg/ha and Boric Acid 10 kg/ha [11]. Different intercultural operations were done as per when needed. After haulm cutting the tubers were kept under the soil for 10 days for skin hardening. After harvesting the potatoes were collected and stored at ambient storage condition. Data were collected up to the sprouting of maximum potatoes.

2.1 Ascorbic Acid Determination

5 gm of tuber sample was taken after meshing in a mortar by using a pestle. Then 10ml of HPO_3 was added in the sample and volume up to the mark. After centrifugation (2000rpm, 10min) it was filtrated and taken 5ml of solution for titration. Then the solution was titrated against indophenol solution and titration record was collected in a notebook. After that in x-axis used concentration of Ascorbic acid (mg) and in y-axis value of titration to find out the standard curve. Then calculated the ascorbic acid as mg/g FW (Fresh Weight).

2.2 Antioxidant Determination

Preparation of the sample was the same as polyphenol determination. Total antioxidant capacity of fresh potatoes was quantified using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method [12]. The absorbance reading was used to calculate spectrophotometer at 517nm wavelength. All the values of antioxidant were expressed as Trolox micrograms per gram fresh weight (Trolox µg/g FW) using a nonlinear regression algorithm from Trolox standard curve.

2.3 Polyphenol Determination

The content of total phenolic compounds was determined spectrophotometrically according to the Folin-Ciocalteu method [13] with slight modification. The absorbance of the reaction solution was measured at 760 nm against a blank sample. The measurement was compared to a standard curve of gallic acid solutions and expressed as microgram of gallic acid equivalents per gram fresh weight (µg GAE/g FW).

2.4 Statistical Analysis

The data collected for different quality characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package program. The significant difference among the treatment means were differentiated by Least Significant Difference (LSD) at 5% level of probability [14].

3. RESULTS AND DISCUSSION

3.1 Ascorbic Acid Content

3.1.1 Effect of variety

Significant variation was found among different varieties to ascorbic acid content of tuber at different storage time. The highest ascorbic acid content of tuber was exhibited by V_3 (73.75 mg, 68.04 mg, 57.97 mg, 51.24 mg) and lowest was exhibited by V_1 (45.62 mg, 39.37 mg, 40.23 mg, 36.37 mg); at 0, 20, 40 and 60 DAS, respectively (Table 1).

3.1.2 Effect of vermicompost

Profound variation was found among different levels of vermicompost on ascorbic acid content of tuber at different storage time. The highest ascorbic acid content was contained by M_4 (79.80 mg, 74.95 mg, 58.40 mg, 52.52 mg) and lowest was contained by M_1 (46.63 mg, 40.20 mg, 37.44 mg, 31.34 mg); at 0, 20, 40 and 60 DAS, respectively (Table 2).

Table 1. Effect of variety on ascorbic acid at different days after storage of potato tuber

Variety	Ascorbic acid (mg/g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
V_1	45.62 d	39.37 d	40.23 d	36.37 d
V_2	57.61 c	53.82 c	44.11 c	39.40 c
V_3	73.75 a	68.04 a	57.97 a	51.24 a
V_4	68.94 b	62.52 b	53.69 b	47.88 b
CV (%)	6.20	4.48	5.30	4.96
$LSD_{0.05}$	2.59	2.51	2.59	2.16
Level of significance	**	**	**	**

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
*** = Significant at 1% level of probability,*
V_1 –BARI TPS-1, V_2 – Lady Rosetta, V_3 – Asterix, V_4 – Courage

Table 2. Effect of vermicompost on ascorbic acid at different days after storage of potato tuber

Vermicompost level	Ascorbic acid (mg/g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
M_1	46.63 d	40.20 d	37.44 d	31.34 d
M_2	55.25 c	48.79 c	48.04 c	43.06 c
M_3	64.23 b	59.80 b	52.10 b	47.97 b
M_4	79.80 a	74.95 a	58.40 a	52.52 a
CV (%)	3.76	4.57	5.33	5.29
$LSD_{0.05}$	1.95	2.15	2.20	1.95
Level of significance	**	**	**	**

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
*** = Significant at 1% level of probability*
M_1 – Control, M_2 – 2 t/ha, M_3 – 4 t/ha, M_4 – 6 t/ha

3.1.3 Combined effect of variety and vermicompost

Significant variation was found among different variety and vermicompost levels on ascorbic acid content of tuber at different storage time. The maximum ascorbic acid content of tuber was contained by V_3M_4 (90.89 mg, 86.78 mg) and minimum was contained by V_1M_1 (36.75 mg, 30.54 mg); at 0 and 20 DAS, respectively. At 40 DAS maximum ascorbic acid content of tuber was contained by V_3M_4 (66.60 mg) which was statistically similar to V_3M_3 and minimum was contained by V_1M_1 (28.54 mg). At 60 DAS maximum ascorbic acid content of tuber was contained by V_3M_4 (59.09 mg) which was statistically similar to V_3M_3 and minimum was contained by V_1M_1 (25.94 mg) (Table 3).

Ascorbic Acid (AA) content significantly decreases during storage condition of potato tuber. The reduction was occurred for the oxidation of ascorbic acid into dehydro ascorbic acid and afterward to diketo-gluconic acid. Being a water-soluble vitamin and susceptible to oxidation, AA contents rapidly decrease with increasing rates of respiration and water loss in storage [15].

Table 3. Combined effect of variety and vermicompost on ascorbic acid at different days after storage of potato tuber

Combination	Ascorbic acid (mg/g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
V_1M_1	36.75 i	30.54 i	28.54 h	25.94 g
V_1M_2	39.50 i	30.58 i	41.67 g	35.54 f
V_1M_3	46.44 h	42.10 g	39.69 g	37.47 f
V_1M_4	59.78 ef	54.24 e	51.01 d	46.54 de
V_2M_1	38.90 i	36.90 h	32.21 h	28.94 g
V_2M_2	47.94 h	42.33 g	38.01 g	33.31 f
V_2M_3	61.81 e	58.40 e	48.99 de	45.20 e
V_2M_4	81.78 c	77.64 b	57.22 c	50.13 cd
V_3M_1	56.01 fg	48.78 f	46.33 ef	37.27 f
V_3M_2	70.10 d	64.72 d	56.39 c	52.40 bc
V_3M_3	77.99 c	71.86 c	62.54 ab	56.20 ab
V_3M_4	90.89 a	86.78 a	66.60 a	59.09 a
V_4M_1	54.86 g	44.57 fg	42.70 fg	33.22 f
V_4M_2	63.48 e	57.54 e	56.10 c	51.00 c
V_4M_3	70.69 d	66.83 d	57.19 c	53.00 bc
V_4M_4	86.74 b	81.13 b	58.76 bc	54.32 bc
CV (%)	3.76	4.57	5.33	5.29
$LSD_{0.05}$	3.89	4.31	4.40	3.89
Level of significance	**	**	**	**

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
*** = Significant at 1% level of probability*
V_1 –BARI TPS-1, V_2 – Lady Rosetta, V_3 – Asterix, V_4 – Courage
M_1 – Control, M_2 – 2 t/ha, M_3 – 4 t/ha, M_4 – 6 t/ha

3.2 Antioxidant Content

3.2.1 Effect of variety

In respect of antioxidant content of tuber at 0 and 40 DAS were found statistically non-significant. At 20 and 60 DAS significant variation was found among different varieties on antioxidant content of tuber. At 20 DAS the highest (22.44 µg) was exhibited by V_3 which was statistically similar to V_4 and the lowest (21.73 µg) was exhibited by V_1. At 60 DAS the highest (27.74 µg) antioxidant content of tuber was exhibited by V_3 which was statistically similar to V_4 and the lowest (26.23 µg) was exhibited by V_1 (Table 4).

3.2.2 Effect of vermicompost

Profound variation was found among different levels of vermicompost on antioxidant content of tuber at different storage time. The highest (21.82 µg, 22.72 µg) antioxidant of tuber was contained by M_4 and the lowest (20.22 µg, 21.48 µg) was contained by M_1, at 0 and 20 DAS, respectively. At 40 DAS the highest (22.94 µg) antioxidant of tuber was contained by M_4 which was statistically similar to M_3 and the lowest (21.65 µg) was contained by M_1. At 60 DAS the highest (27.95 µg) antioxidant of tuber was contained by M_4 and the lowest (26.00 µg) was contained by M_1 (Table 5).

3.2.3 Combined effect of variety and vermicompost

No significant variation was found among different variety and vermicompost levels on antioxidant content of tuber at 0, 20 and 40 DAS. At 60 DAS due to different variety and vermicompost levels was found statistically significant. The maximum (28.43 µg) antioxidant content of tuber contained by V_3M_4 which was statistically similar to V_3M_3 and V_4M_4. The minimum (25.27 µg) antioxidant was contained by V_1M_1 (Table 6).

The activity of total antioxidant increased from harvesting to eight weeks of storage time and its activity varied with genotypic responses over storage period [16].

Table 4. Effect of variety to antioxidant at different days after storage of potato tuber

Variety	Antioxidant (Trolox µg/g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
V_1	20.49	21.73 c	22.15	26.23 c
V_2	20.83	21.96 bc	22.28	26.81 b
V_3	21.43	22.44 a	22.58	27.74 a
V_4	21.09	22.17 ab	22.44	27.34 a
CV (%)	5.21	1.55	2.32	1.72
$LSD_{0.05}$	-	0.341	-	0.465
Level of significance	NS	**	NS	**

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
*** = Significant at 1% level of probability, NS = Not significant*
V_1 –BARI TPS-1, V_2 – Lady Rosetta, V_3 – Asterix, V_4 – Courage

Table 5. Effect of vermicompost on antioxidant at different days after storage of potato tuber

Vermicompost level	Antioxidant (Trolox µg/ g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
M_1	20.22 c	21.48 d	21.65 c	26.00 d
M_2	20.73 b	21.81 c	22.26 b	26.80 c
M_3	21.07 b	22.28 b	22.60 ab	27.38 b
M_4	21.82 a	22.72 a	22.94 a	27.95 a
CV (%)	2.14	1.61	1.90	1.39
$LSD_{0.05}$	0.377	0.299	0.357	0.317
Level of significance	**	**	**	**

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
*** = Significant at 1% level of probability*
M_1– Control, M_2 – 2 t/ha, M_3 – 4 t/ha, M_4 – 6 t/ha

Table 6. Combined effect of variety and vermicompost on antioxidant at different days after storage of potato tuber

Combination	Antioxidant (Trolox µg/ g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
V_1M_1	19.45	21.20	21.23	25.27 e
V_1M_2	20.31	21.53	22.12	25.62 e
V_1M_3	20.67	21.66	22.52	26.35 d
V_1M_4	21.51	22.51	22.74	27.67 b
V_2M_1	20.33	21.30	21.58	25.54 e
V_2M_2	20.61	21.58	22.19	26.46 d
V_2M_3	20.78	22.43	22.56	27.55 bc
V_2M_4	21.60	22.52	22.81	27.69 b
V_3M_1	20.61	21.84	21.97	26.91 cd
V_3M_2	21.20	22.27	22.45	27.62 b
V_3M_3	21.49	22.57	22.69	28.01 ab
V_3M_4	22.43	23.09	23.20	28.43 a
V_4M_1	20.51	21.57	21.84	26.28 d
V_4M_2	20.81	21.88	22.26	27.48 bc
V_4M_3	21.32	22.48	22.64	27.60 b
V_4M_4	21.72	22.74	23.01	28.00 ab
CV (%)	2.14	1.61	1.90	1.39
$LSD_{0.05}$	0.755	0.598	0.715	0.635
Level of significance	NS	NS	NS	*

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
*** = Significant at 1% level of probability, NS = Not significant*
V_1 –BARI TPS-1, V_2 – Lady Rosetta, V_3 – Asterix, V_4 – Courage
M_1 – Control, M_2 – 2 t/ha, M_3 – 4 t/ha, M_4 – 6 t/ha

3.3 Polyphenol Content

3.3.1 Effect of variety

Significant variation was found among different varieties to polyphenol content of tuber at different storage time. At 0 DAS the highest (0.6542 mg) polyphenol content of tuber was exhibited by V_3 and the lowest (0.3525 mg) was exhibited by V_1. At 20 DAS the highest (0.4371 mg) polyphenol content of tuber was exhibited by V_3 which was statistically similar to V_4 and the lowest (0.2734 mg) was exhibited by V_1. At 40 DAS the highest (0.1610 mg) polyphenol content of tuber was exhibited by V_3 and the lowest (0.1091 mg) was exhibited by V_1. At 60 DAS the highest (0.1303 mg) polyphenol content of tuber was exhibited by V_3 which was statistically similar to V_4 and the lowest (0.08275 mg) was exhibited by V_1 (Fig. 1).

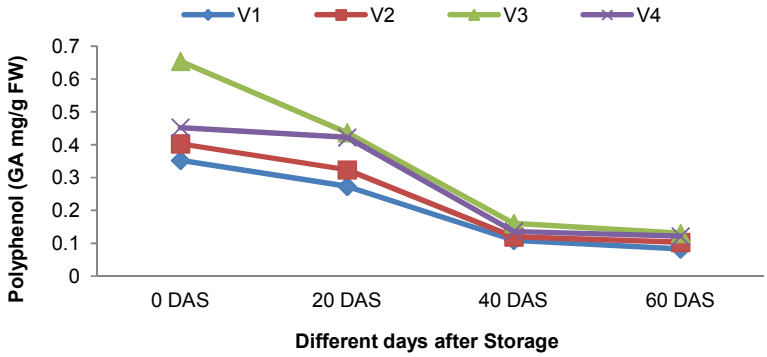

Fig. 1. Effect of variety to polyphenol content of tuber at different days after storage
(LSD values 0.031, 0.0757, 0.0070 and 0.0170 for 0 DAS, 20 DAS, 40 DAS and 60 DAS, respectively). V_1–BARI TPS-1, V_2– Lady Rosetta, V_3– Asterix, V_4– Courage

3.3.2 Effect of vermicompost

Profound variation was found among different levels of vermicompost on polyphenol content of tuber at different storage time. At 0 DAS the highest (0.6667 mg) polyphenol of tuber was contained by M_4 and the lowest (0.2875 mg) was contained by M_1 (Fig. 2). At 20 DAS the highest (0.4146 mg) polyphenol of tuber was contained by M_4 which was statistically similar to M_1 and the lowest (0.2457 mg) was contained by M_2. At 40 DAS the highest (0.1662 mg) polyphenol of tuber was contained by M_4 and the lowest (0.1108 mg) was contained by M_1 which was statistically similar to M_2. At 60 DAS the highest (0.1411 mg) polyphenol of tuber was contained by M_4 and the lowest (0.0778 mg) was contained by M_1 (Fig. 2).

3.3.3 Combined effect of variety and vermicompost

Significant variation was found among different variety and vermicompost levels on polyphenol content of tuber at Different storage time. At 0 DAS the maximum (1.08 mg) polyphenol of tuber contained by V_3M_4 and the minimum (0.180 mg) was contained by V_1M_1. At 20 DAS the maximum (0.571 mg) polyphenol of tuber contained by V_4M_1 which was statistically similar to V_3M_3 and V_3M_4. The minimum (0.127 mg) was contained by V_1M_1. At 40 DAS the maximum (0.2290 mg) polyphenol of tuber contained by V_3M_4 and the minimum (0.09100 mg) was contained by V_1M_1. At 60 DAS due to different varieties and vermicompost levels was found statistically non-significant (Table 7).

The total amount of phenolics in potato varies significantly among different varieties [17]. Polyphenol oxidase (PPO) activity increases in potato due to the availability of substrate and its subsequent oxidation during storage. The prominent increase in the PPO activity in different treatments after the 1st month till the end of the storage period might be associated with an increased substrate (polyphenol) oxidation. A high amount of phenolics during storage is attributed to low PPO and high antioxidant activity in potatoes [18]. Studies revealed that the phenolics content in potato continued to increase during storage period until the onset of PPO activity [19]. Kulen et al. [20] demonstrated that storage time is also very important for phenolic compounds. They found that the total phenolic content (TPC) of potatoes was high at harvest, declined after two months of ambient storage.

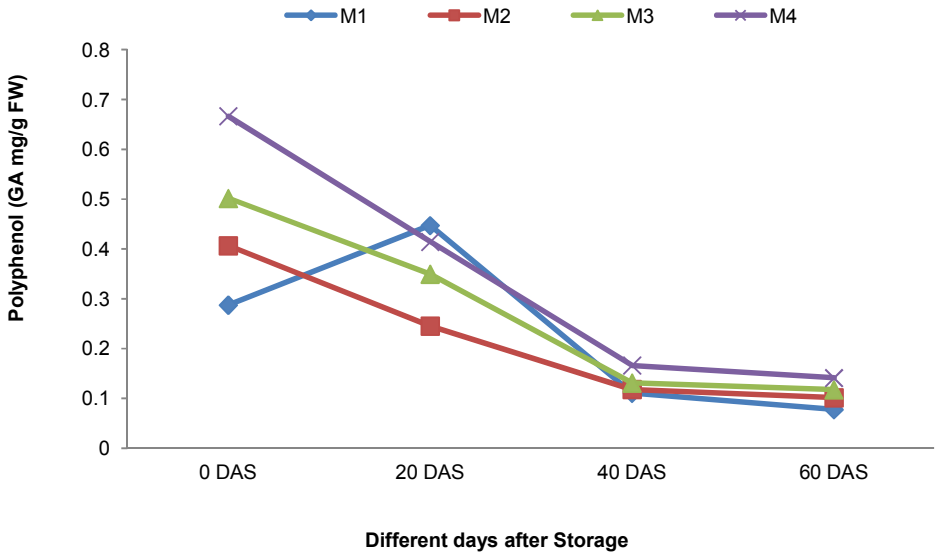

Fig. 2. Effect of vermicompost on polyphenol content of potato tuber at different days after storage

(LSD values 0.026, 0.0449, 0.0092 and 0.0162 for 0 DAS, 20 DAS, 40 DAS and 60 DAS, respectively). M_1 – Control, M_2 – 2 t/ha, M_3 – 4 t/ha, M_4 – 6 t/ha

Table 7. Combined effect of variety and vermicompost on a polyphenol at different days after storage of potato tuber

Combination	Polyphenol (GA mg/g FW)			
	0 DAS	20 DAS	40 DAS	60 DAS
V_1M_1	0.180 k	0.407 b-d	0.09100 h	0.06
V_1M_2	0.330 hi	0.127 h	0.1060 gh	0.09
V_1M_3	0.400 fg	0.240 g	0.1123 fg	0.09
V_1M_4	0.500 de	0.319 d-g	0.1270 d-f	0.09
V_2M_1	0.260 j	0.375 c-e	0.1053 gh	0.08
V_2M_2	0.370 gh	0.252 g	0.1060 f-h	0.10
V_2M_3	0.456 ef	0.296 e-g	0.1190 e-g	0.10
V_2M_4	0.526 cd	0.372 c-f	0.1490 bc	0.13
V_3M_1	0.420 fg	0.436 bc	0.1260 d-g	0.09
V_3M_2	0.496 de	0.329 d-g	0.1380 c-e	0.11
V_3M_3	0.620 b	0.482 ab	0.1510 bc	0.14
V_3M_4	1.08 a	0.501 ab	0.2290 a	0.18
V_4M_1	0.290 ij	0.571 a	0.1210 e-g	0.08
V_4M_2	0.430 f	0.274 fg	0.1220 e-g	0.11
V_4M_3	0.530 cd	0.381 c-e	0.1427 b-d	0.14
V_4M_4	0.560 c	0.466 bc	0.1597 b	0.16
CV (%)	7.51	14.53	8.32	17.46
$LSD_{0.05}$	0.053	0.089	0.018	-
Level of significance	**	*	**	NS

Numbers in columns followed by the same letter are not statistically different at $P_{0.05}$.
** = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant*
V_1 –BARI TPS-1, V_2 – Lady Rosetta, V_3 – Asterix, V_4 – Courage
M_1 – Control, M_2 – 2 t/ha, M_3 – 4 t/ha, M_4 – 6 t/ha

4. CONCLUSIONS

Tuber produced from V_3M_4 contained maximum ascorbic acid (Vitamin C), antioxidant and polyphenol; whereas the V_1M_1 was exhibited worst one. In conclusion, the potato growers of Bangladesh may apply vermicompost on their field at the rate of 6 tons per hectare to improve quality in the combination of BARI Alu-25 (Asterix) and BARI Alu-29 (Courage); can also store at ambient condition up to 60 days after storage (DAS) without degrading significant quality parameters.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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