International Journal of Agricultural and Applied Sciences, December 2021, 2(2):28-33
https://www.agetds.com/ijaas
ISSN: 2582-8053
https://doi.org/10.52804/ijaas2021.225

Research Article

OPEN ACCESS

Biochemical and sensory traits of potato for processing purpose as influenced by vermicompost and potassium sources

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(**Received:** 13/06/2021; **Revised:** 10/09/2021; **Accepted:** 05/10/2021)

ABSTRACT
Production of low-quality potato is the main constraint for increasing the processing and export scenario in Bangladesh. Hence, application of different sources of potassium and vermicompost may improve the biochemical and sensory quality of potato. The experiment was conducted to assess the effect of potassium sources and vermicompost level on the yield and processing quality of potato. The potato variety BARI Alu-25 (Asterix) was used as test crop for this experiment. The experiment consisted of two factors: Factor A: 3 sources of Potassium as- K_1: KCl, K_2: KNO_3, K_3: K_2SO_4; Factor B: 4 levels of vermicompost as-Vm_0: 0 ton, Vm_1: 4 ton, Vm_2: 8 ton, and Vm_3: 12 ton. The experiment was laid out in a split-plot design with three replications. Results revealed that the highest dry matter content (19.83%), specific gravity (1.090 g/cc), and starch (14.81%) were recorded from K_2SO_4, whereas, the lowest from KNO_3. The firmness, dry matter content, specific gravity, and starch content increased with increasing the vermicompost level. A negative relation was observed in the case of TSS and sugar content. Among the 12 treatment combinations, the highest dry matter content (21.12%), specific gravity (1.103 g/cc), and starch (16.34%) were found from K_3Vm_3, whereas, the lowest from K_2Vm_0 treatment. However, K_1Vm_2, K_1Vm_3, K_3Vm_2, K_3Vm_3 showed statistically similar results regarding quality attributes. But the availability of potassium sources and economic point of view, KCl combined with 8-ton vermicompost ha^{-1} could be used for the production of good quality potato.
Keywords: Vermicompost, potassium source, sugar, starch, dry matter, and potato.

INTRODUCTION
Solanum tuberosum L. named as "Potato" belongs to the family *Solanaceae* is that the fourth-largest world food crop after rice, wheat, and maize (Ahmed *et al*., 2017; Chakraborty *et al*., 2010; Haas *et al*., 2009) also called as the "kings of vegetable". The acreage, production and yield of potato In Bangladesh are 0.48 million hectares, 0.974 crore MT and 20.41 t ha^{-1}, respectively, and therefore, the yield of potato is relatively low as compared to those of USA (47.15 t ha^{-1}), France (54.19 t ha^{-1}) (FAOSTAT, 2018). The utilization of poor-quality seed tubers and non-judicial agronomic practices are the prominent reasons for lower yield. Potato tuber quality is one among the foremost important quality attributes for consumers, industrial demand and for the export market (Roy *et al*., 2017 and Brown, 2005). High dry matter content in tuber exhibited better processing quality of potato (Abong *et al.*, 2009). The chip yield, crispy consistency, and oil absorption during cooking are decided by the high dry matter content in potato tubers (Pedreschi *et al.*, 2005; Rommens *et al.*, 2010). The factors like soil and climate, agronomic techniques, biological and cultivar specifics etc. can varies the potato yields and tuber quality. The judicial use of fertilizers and manures ensured a 30-50% yield increase resulted excellent tubers quality while preserving soil fertility. With balanced fertilization the potato crop yield and quality can be enhanced significantly. Potato plants require extreme more K than the other vegetable crop for tuber skin hardening. This crop sometimes is considered an indicator crop for K^+ availability due to its high K^+ requirement (Ulrich *et al.*, 1966). For the synthesis of straight forward starch and within the translocation of carbohydrates potassium is a prominent nutrient element in potato plants (Smith and Smith, 1977). The processing and export standard of potato tubers also can be improved to an excellent extent with K use. Different sources of potassium *e.g.*, KCl, KNO_3, K_2SO_4 varying quality parameters of potato. Vermicompost, the excreta of the earthworm, can improve the health and nutrients of the soil and is the best compared to other traditional compost (Joshi *et al*., 2015). The organic waste has been converted into nutrient-rich manure by the action of earthworms which named as the process of vermicomposting. The characteristic feature of vermicomposts like high

porosity and moisture holding capacity increa the expansion of plants (Tisdale *et. al.*, 1985). It has 1.5 2.2% nitrogen (N), 1.8-2.2% phosphorus (P), and 1.0-1.5% potassium (K) on average with organic carbon is between 9.15 and 17.98%, and has micronutrients like sodium (Na), calcium (Ca), zinc (Zn), sulfur (S), magnesium (Mg), and iron (Fe) (Adhikary, 2012). The retention of soil water, regulation of the soil temperature and structure, enhancement of the soil with nutrient elements, and increment of the biomass and community structure of the microbial population are the basic role of vermicomposting in soil (Vivas *et al.*, 2009). Vermicompost acted as a fertilizer and soil conditioner (Chakraborty *et al.*, 2003) and liable for the improvement of the soil's physical properties and also make sure the supply of major plant nutrients (Nardi *et. al.*, 2002; Klavins *et al.*, 2004; Smith *et al.*, 2014). The application of vermicompost may increase the processing quality of potatoes. Sometimes potato produced in Bangladesh isn't good quality enough in respect of dry matter content, which isn't present at optimum level in produced product. So, using different sources of potassium and level of vermicompost respectively may put contribution to improving the qualities of potato with our scarifying yield. The effects of potassium sources and vermicompost level on the processing quality of potatose are still unknown, especially in Bangladesh condition. Therefore, the present study was conducted to study the effect of various sources of potassium and vermicompost level on different processing qualities of potato.

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from the period of November 2019 to May 2020. The experimental area was belonged to 23°7'N latitude and 93°E' longitude at an altitude of 8.6 meters above sea level. The soil was also characterized by pH-5.62 and organic carbon-0.456% (Analyzed from Soil Resources Development Institute, Dhaka). The research area is occupied with complete annual rainfall was 24.23 mm with average monthly maximum and minimum temperature of 29.64°C and 14.91°C, respectively. The potato variety BARI Alu-25 (Asterix) was used as test crop. The present experiment comprised of two factors *viz.*, Factor A: 3 sources of Potassium; I K_1: KCl (260 kg KCl ha^{-1} @130 kg K ha^{-1}); ii. K_2: KNO_3 (336.09 kg KNO_3 ha^{-1} @130 kg K ha^{-1}); iii. K_3: K_2SO_4 (309.2 kg K_2SO_4 ha^{-1} @130 kg K ha^{-1}) and Factor B: 4 Levels of vermicompost; i. Vm_0: 0 ton vermicompost ha-^{1}; ii. Vm_1: 4 ton vermicompost ha^{-1}; iii. Vm_2: 8 ton vermicompost ha^{-1}; iii. Vm_2: 8 ton vermicompost ha^{-1}. iv. Vm_3: 12 ton vermicompost ha-^{1}. The experiment was laid out in a split-plot design with three replications. Different sources of potassium were assigned to the main plot and vermicompost level to sub-plot. Sprouted potato tubers were used as planting material. The allocated plots were fertilized by recommended doses of urea 325 kg ha^{-1}, Triple Super Phosphate (TSP) 200 kg ha^{-1}, gypsum 100 kg ha^{-1}, zinc sulfate 8 kg ha^{-1} and except treatments (BARI, 2019). All the intercultural operations and plant protection measures were taken as per when needed. After haulm cutting, the tubers were kept under the soil for 7 days for skin hardening. Firmness was estimated by using a pressure gauge. For the estimation of firmness firstly the potato tubers was divided into two then created pressure using pressure gage and recorded the reading from the pressure gauge. Total Soluble Solids (TSS) of harvested tubers was determined following methods used by (Ferdous *et al.*, 2019a) and recorded as °brix. The dry matter contents in potato tubers were computed following by given calculation (Ferdous *et al.*, 2019b). The specific gravity of potato tubers was measured using the subsequent formula described by (Ferdous *et al.*, 2019b). The starch and sugar content of potato tubers was determined after harvest following methods described by (Ferdous *et al.*, 2019a). The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test using MSTAT-C software. The difference among the treatments and treatment combinations of means under the experiment was estimated by Duncan's Multiple Range Test (DMRT) at a 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Firmness (N)

Different sources of potassium varied non-significantly in terms of the firmness of potato tubers (Table 3). The highest firmness score of potato tubers (39.76 N) was found from K_1, while the lowest score (38.92 N) was recorded from K_2. The firmness of potato tubers showed statistically significant differences due to different levels of vermicompost (Table 1). Firmness was significantly maximum with a higher level of vermicompost. The tuber belonging highest firmness does not lose too much water. Statistically, significant variation was recorded in terms of the firmness score of potato tubers due to the combined effect of different sources of potassium and levels of vermicompost (Table 2). The highest firmness of potato tubers (44.01 N) was found from K_1Vm_3 which was statistically similar to K_1Vm_2, K_3Vm_2, and K_3Vm_3 (42.49 N, 41.11 N, and 41.00 N) while the lowest score (34.65 N) was observed from the K_2Vm_0 treatment combination.

Total soluble solids (TSS-°brix)

Statistically, non-significant variation was recorded in terms of TSS of potato tubers due to different sources of potassium (Table 1). The highest TSS in potato tubers (3.97 ^{0}Brix) was recorded from K_1, whereas the lowest (3.89 ^{0}Brix) was found in K_2.TSS of potato tubers showed statistically significant differences due to different levels of vermicompost (Table 1). TSS decreases with the increasing level of vermicompost. A statistically significant difference was observed in terms of TSS in potato tubers due to the combined effect of different sources of potassium and levels of vermicompost (Table 2). The highest TSS in potato tubers (4.38 ^{0}Brix) was observed from K_1Vm_0, whereas the lowest (3.45 ^{0}Brix) from K_2Vm_3 is statistically similar to K_1Vm_3 and K_3Vm_3 (3.58 and 3.56 ^{0}Brix) treatment combination. The lower TSS, the higher chances of good quality potato.

Table 1. Effect of different sources of potassium and levels of vermicompost on biochemical and sensory traits of potato

Treatments	Firmness (N)	Total soluble solids-TSS (^{0}Brix)	Dry matter (%)	Specific gravity (g/cc)	Starch (%)	Sugar (%)
Source of potassium						
K_1	39.76	3.97	19.20 ab	1.072 b	14.04 b	1.191 b
K_2	38.92	3.89	18.74 b	1.043 c	13.63 b	1.220 ab
K_3	39.29	3.93	19.83 a	1.090 a	14.81 a	1.245 a
SE	0.404	0.027	0.176	0.006	0.175	0.009
F-test	NS	NS	*	**	*	*
RSD (%)	3.56	2.41	3.17	1.94	4.28	2.59
Levels of vermicompost						
Vm_0	35.26 c	4.19 a	17.57 c	1.046 b	11.96 c	1.323 a
Vm_1	38.61 b	4.12 a	19.08 b	1.067 ab	13.88 b	1.233 b
Vm_2	41.30 a	3.88 b	20.14 a	1.077 ab	15.19 a	1.199 b
Vm_3	42.12 a	3.53 c	20.24 a	1.083 a	15.61 a	1.119 c
SE	0.616	0.042	0.267	0.009	0.172	0.013
F-test	**	**	**	*	**	**
RSD (%)	4.70	3.19	4.16	4.40	5.64	3.27

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; * = Significant at 5% level; ** = Significant at 1% level; NS= non-significant; K_1: KCl, K_2: KNO_3, K_3: K_2SO_4, Vm_0: 0 ton ha^{-1}, Vm_1: 4 ton ha^{-1}, Vm_2: 8 ton ha^{-1}, Vm_3: 12 ton ha^{-1}

Table 2. Combined effect of different sources of potassium and levels of vermicompost on biochemical and sensory traits of potato

Interaction	Firmness (N)	Total soluble solids –TSS (^{0}Brix)	Dry matter (%)	Specific gravity (g/cc)	Starch (%)	Sugar (%)
K_1Vm_0	35.58 d	4.38 a	17.22 e	1.053 ab	11.83 gh	1.288 ab
K_1Vm_1	36.97 cd	4.22 ab	19.12 bcd	1.070 ab	13.97 de	1.233 bc
K_1Vm_2	42.49 ab	3.73 d	19.92 abc	1.073 ab	14.40 cd	1.162 cde
K_1Vm_3	44.01 a	3.58 de	20.52 ab	1.090 a	15.97 ab	1.081 e
K_2Vm_0	34.65 d	4.11 bc	17.17 e	1.013 b	11.50 h	1.327 a
K_2Vm_1	39.39 bc	4.04 bc	18.97 cd	1.027 b	13.27 ef	1.190 cd
K_2Vm_2	40.31 bc	3.96 c	19.74 a-d	1.067 ab	15.23 bc	1.211 bc
K_2Vm_3	41.35 ab	3.45 e	19.07 bcd	1.063 ab	14.53 cd	1.153 cde
K_3Vm_0	35.56 d	4.09 bc	18.32 de	1.070 ab	12.54 fg	1.355 a
K_3Vm_1	39.47 bc	4.11 bc	19.15 bcd	1.097 a	14.41 cd	1.277 ab
K_3Vm_2	41.11 ab	3.95 c	20.75 a	1.090 a	15.94 ab	1.224 bc
K_3Vm_3	41.00 ab	3.56 de	21.12 a	1.103 a	16.34 a	1.122 de
SE	1.066	0.072	0.463	0.015	0.298	0.023
F-test	*	*	*	*	*	*
RSD (%)	4.70	3.19	4.16	4.40	5.64	3.27

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability; * = Significant at 5% level; K_1: KCl, K_2: KNO_3, K_3: K_2SO_4, Vm_0: 0 ton ha^{-1}, Vm_1: 4 ton ha^{-1}, Vm_2: 8 ton ha^{-1}, Vm_3: 12 ton ha^{-1}

Dry matter (%)

Statistically, significant variation was recorded in terms of dry matter content in potato tubers due to different sources of potassium (Table 1). The highest dry matter content in potato tubers (19.83%) was recorded from K_3 which was statistically similar (19.20%) to K_1, while the lowest (18.74%) was found from K_2. The appliance of K fertilizer within the sort of sulphate as compared to chloride increased dry matter content (Manolov *et al*., 2005). This could be due to the physiological effect of chloride on the enzyme activity of plants. Different levels of vermicompost varied significantly in terms of dry matter content in potato tubers Table 1). With the increasing level of vermicompost dry matter content of a tuber also increases. Ferdous *et al*. (2019b) reported that dry matter (%) increased with increasing vermicompost levels. Dry matter content in potato tubers showed statistically significant differences due to the combined effect of various sources of potassium and levels of vermicompost (Table 2). The highest dry matter content in potato tubers (21.12%) was observed from K_3Vm_3 which is statistically similar to K_3Vm_2, K_1Vm_3, and K_1Vm_3(20.75%, 20.52% and 19.92 %) the lowest (17.17%) was recorded from the K_2Vm_0 treatment combination.

Specific gravity (g/cc)

Different sources of potassium varied significantly in terms of the specific gravity of potato tubers (Table 1). The highest specific gravity of potato tubers (1.090 g/cc) was found from K_3 which was followed (1.072 g/cc) by K_1 and therefore, the lowest (1.043 g/cc) was observed from K_2. The specific gravity was more in SOP treated plants than treated with MOP ones. The specific gravity of potato tubers showed statistically significant differences due to different levels of vermicompost (Table 1). Specific gravity increases with the increasing level of vermicompost. Ferdous *et al*. (2019b) reported that specific gravity increased with increasing vermicompost levels. Statistically, significant variation was recorded in terms of specific grthe avity of potato tubers due to the combined effect of different sources of potassium and levels of vermicompost (Table 2). The highest specific gravity of potato tubers (1.103 g/cc) was recorded from K_3Vm_3, whereas, the lowest (1.013 g/cc) was found from K_2Vm_0. The specific gravity may be measure of quality in potato tuber which is said to be the dry matter contents within the tubers. There are many factors that affect the specific gravity like potato variety, location and fertil,izer used, etc. (Marwaha *et al*., 2010). The specific gravity is additionally related to starch content, total solids, and mealiness of potato tubers (Yakimenko *et al*., 2018). A reduction in specific gravity due to fertilizer treatment and its influence on crop quality. The higher the specific gravity, the upper will be the quantity of dry matter and therefore, the greater the yield of produce. Potato with high specific gravity is preferred for the preparation of chips and French-fried potato. Potato with low specific gravity is used for canning. However, potato with very high specific gravity (1.10 g/cc) may not be suitable for French fry potato production because they become hard or biscuit-like. So, the purpose of growing potato should be kept in mind.

Starch (%)

Starch content in potato tubers varied significantly due to the different sources of potassium (Table 3). The highest starch content in potato tubers (14.81%) was observed from K_3, whereas the lowest starch content (13.63%) from K_2 was statistically similar (14.04%) to K_1. Statistically significant variation was observed in terms of starch content in potato tubers due to different levels of vermicompost (Table 1). With the increasing level of vermicompost starch content also increases. The combined effect of different sources of potassium and levels of vermicompost showed statistically significant differences in terms of starch content in potato tubers (Table 2). The highest starch content in potato tubers (16.34%) was recorded from K_3Vm_3 which is statistically similar to K_3Vm_2 and K_1Vm_3 (15.94% and 15.97%), whereas, the lowest (11.50%) was observed from the K_2Vm_0 treatment combination. Potassium plays a crucial role in the activation of starch synthetase, a key enzyme controlling the incorporation of glucose into long-chain starch molecules (Bhattarai and Swarnima, 2016). Moreover, potassium helps in the translocation of starch from leaves to tubers. The beneficial effect of manure additions might be attributed to improved soil-water-air relationship, thereby, encouraging better root prolife, leading to higher K uptake and consequently higher starch contents (Ulrich and Ohki, 1966).

Sugar (%)

Sugar content in potato tubers varied significantly due to different sources of potassium (Table 1). The highest sugar content in potato tubers (1.245%) was found from K_3 which was statistically similar (1.220%) to K_2, whereas the lowest (1.191%) was observed from K_1. Sugars ratio was being influenced by potassium sources (Tekalign, 2011). Sugar content increased in potato tubers with K application (Klavins *et al*., 2004). Statistically, significant variation was obtained in terms of sugar content in potato tubers due to different levels of vermicompost (Table 1). Sugar percentage decreases with the increasing level of vermicompost. The combined effect of different sources of potassium and levels of vermicompost showed statistically significant differences in terms of sugar content in potato tubers (Table 2). The highest sugar content in potato tubers (1.355%) was found from K_3Vm, whereas the lowest (1.081%) was recorded from K_1Vm_3 which was statistically similar to K_3Vm_3 (1.122%) treatment combination. The lower percentage of sugar content, the higher quality of potato tuber.

Correlation Coefficient (r)

The correlation was calculated on the idea of knowledge from harvesting day. In Figure.1, a positive linear relation (r= 0.75) is presented between dry matter percentage and specific gravity. In Figure-2, a strongly positive relation (r= 0.96) is presented between dry matter percentage and starch of potato tuber. In Figure.3, a negative relation (r= -0.77) is presented between dry matter percentage and sugar content of tuber.

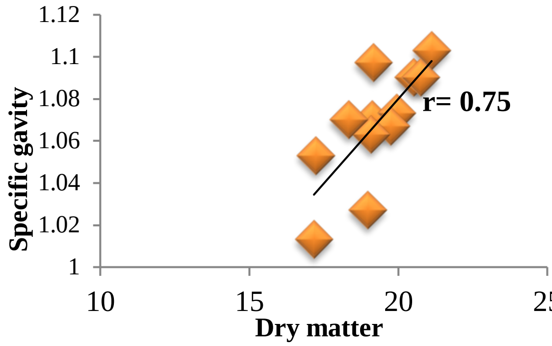

Figure 1. A relationship between dry matter and specific gravity of potato tuber

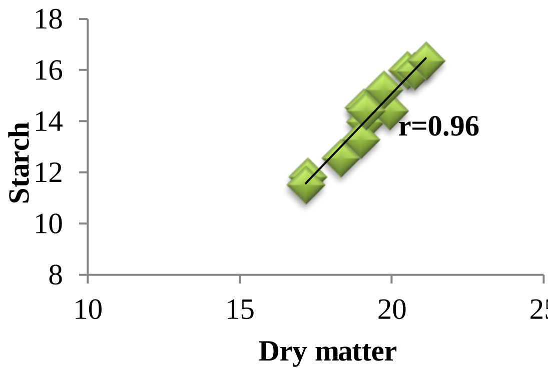

Figure 2. A relationship between dry matter and starch content of potato tuber

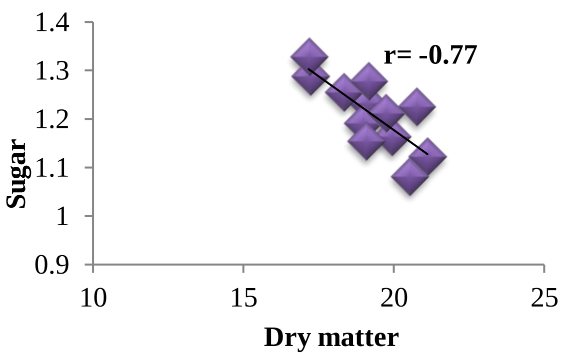

Figure 3. A relationship between dry matter and sugar content of potato tuber

CONCLUSION

Findings revealed that sources of potassium varied significantly varied for different quality attributes of potato. Among the sources, KCl and K_2SO_4 performed better than KNO_3 considering the quality of potato. Among different levels of vermicompost 12-ton vermicompost, ha^{-1} performed better but it was statistically similar with 8-ton vermicompost ha^{-1}. KCl and K_2SO_4 as a source of potassium and 8 and 12-ton vermicompost ha^{-1} produced good processing quality potato. However, in Bangladesh condition availability and economic point of view, KCl combined with 8-ton vermicompost ha^{-1} would be used for producing processing quality of potato without sacrificing yield.

ACKNOWLEDGEMENT

This study was supported by PIU-NATP-2, ID NO. 020, BARC, Farmgate, Dhaka, Bangladesh.

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Citation: Badrunnesa, A.; Chakraborty, R.; Chakraborty, E. and Roy, T.S. 2021. Organic pollutants in wastewater and its remediation approaches using graphene adsorbent. *International Journal of Agricultural and Applied Sciences*, **2**(2):28-33. https://doi.org/10.52804/ijaas2021.225

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