Analysis of Nutrient Content and Quality Evaluation of Grafted Tomato Grown over Wild Eggplant S. *sisymbrilifolium*, by a Novel Grafting Technique

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Abstract

The nutrient and antinutrient composition of grafted tomato was determined and compared with that of a non-grafted control. No marked differences in the proximate composition were found between the two kinds of tomato. However, protein content of the grafted tomato was about 24.35% higher than the control (control, 1.15g/100g; Grafted-I, 1.43g/100g) with a concomitantly lower carbohydrate content. Of the minerals, calcium and iron were significantly higher in grafted tomato than the control whereas the content of sodium and copper was significantly lower. Antinutritional factor phytic acid decreased significantly, oxalic acid remained unaffected, and tannin increased substantially in grafted tomato than the control. The contents of the antinutritents were far below the toxic level. The overall nutritional quality and safety of the grafted tomato is similar and hence "substantially equivalent" to the non-grafted control.

Introduction

Yield of Rabi (winter) vegetable in Bangladesh is determined by a number of interactions of climate, soil type, seed and cultivation techniques, and management parameters. However, cultivation technique is of primary importance. Recently high yield of tomato has been ensured using a grafting technique[1]. Grafting is a propagation method, which involves the union of two separate stems, and continues to grow as one plant. In general, grafting is practiced in different plants like mango, rose, and jujube for certain advantages viz., growing different types of flowers or fruits on a same plant, converting shy bearing/alternate bearing trees of poor quality fruits into superior quality fruit-plants, reducing insects and diseases etc. Use of this technique in vegetable production is quite a recent event.

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In Bangladesh, tomato production is very often heavily affected by soil borne diseases resulting a low plant population and low yield. Early cultivation of tomato is difficult due to high incidence of root diseases like bacterial wilt, fusarium wilt, verticillium wilt and root-knot nematodes as well as due to some of the soil borne viruses. On the other hand, some wild Solanum species have been found resistant to many of these soil borne diseases. But transfer of the resistance properties from wild eggplants to cultivated eggplant or tomato is very difficult through conventional propagation techniques and have not been successful either. During the late nineties Ali *et al.*[1] in Japan first successfully produced excellent quality of tomato fruits by grafting tomato plant on wild eggplant rootstocks. The superiority of this method is that it produced excellent quality of tomato fruits without hollowness, which was a decade-old problem for grafted tomato. Eventually many eggplants were evaluated as rootstocks for tomato such as *s. sisymbrilifolium, s. torvum,* and *s. fexor* which are widely available in Bangladesh.

Although high fruit quality and yield were ensured by this grafting technique[2], studies on the nutritional analysis and quality, and safety evaluation are rare. In Bangladesh, no such study has been conducted yet with grafted tomato. The present article describes the nutritive value of grafted tomato by analyzing quantitatively its nutrient composition and antinutritional factors. Its safety according to the established scientific concepts of "substantial equivalence" and "familiarity" was also compared with non-grafted control cultivated simultaneously.

Materials and Methods

Two varieties of tomato, Ratan (Grafted-I) and Tm-0126 (Grafted-II), were used in this study for grafting. Non-grafted Ratan variety was used as control for grafted Ratan variety whereas Tm-0126 variety was used for inter-variety comparison. All these varieties of tomato were cultivated in the field of Bangabandhu Agricultural University (former IPSA, Institute of Postgraduate Studies in Agriculture) Salna, Gazipur, Bangladesh.

Sample Preparation

Following collection, the fruits were cleaned and washed with water. Weight of each fruit was recorded and then packed in a polyethylene bag, stored at -20°C until analysis. For analysis, tomato samples were mashed in a mortar to make a paste and aliquots were taken for estimations. In case of dry samples, mashed tomato was dried in an oven at 105°C for 5h.

Analytical Procedures

Compositional analysis of the grafted and non-grafted tomato samples was performed in tirplicate or quadruplicate. Moisture content was determined by weight loss of the sample on drying at 105°C for 5 h [3]. Protein content was calculated from total nitrogen by using N x 6.25 after determination of the total nitrogen by semi-micro Kjeldhal method[4]. Lipid was determined by AOAC official method 922.06[4]. Crude fiber was determined by the method of ICOMR[3]. The sample was charred and ashed to a constant weight, the residue being quantified as ash by AOAC official method 942.05[4]. The nitrogen free extracts (NFE) were considered as total carbohydrate and was calculated by the following equation : Carbohydrate (g/100g) = 100 - (moisture + protein + lipid + fiber + ash) g/100 g.

Energy value of the samples was estimated and expressed in kilocalories by multiplying the percentage of protein, lipid and carbohydrate by the Atwater-Bryant factors 4, 9 and 4 respectively.

Mineral contents were assayed using an atomic absorbance spectrophotometer (Pye Unicam SP-9) according to Milner and Whiteside[5]. Vitamin C content was estimated by 2, 4 - dinitro-phenylhydrazine method[6] and β -carotene was estimate by the method of Holden[7] with a minor modification. Antinutritional factor, phytic acid was extracted with 1.5% hydrochloric acid in 10% sodium sulphate and precipitated as ferric salt. The concentration of iron was read by atomic absorbance spectrophotometer and iron concentration was converted to phytic acid by multiplying with a constant value[8]. Both oxalic acid and tannin were estimated by AOAC methods[4]. Oxalic acid precipitated as calcium salt was read by atomic absorbance spectrophotometer while tannin was determined by using Folin-Denis reagent and measured by a spectrophotometer at 760 nm.

Statistical Analysis

The data are expressed as the mean and standard deviation. The difference of the means between grafted and nongrafted tomato were tested using onc way analysis of variance followed by Duncan's multiple range test at the level of $p<0.05$.

Results

Fruit quality of grafted tomato

The size and shape of the grafted tomatoes were similarly improved as reported earlier[2] in comparison to nongrafted controls. The fruits used for subsequent experiments were on average larger ones.

Compositional analysis

(i) Proximate composition

No significant differences were found in the levels of moisture, lipid, ash and carbohydrate between the control and grafted tomato samples (Table 1). However, the protein content in Grafted-I tomato was substantially higher (24.35% more) than the control in association with a lower carbohydrate content (13.77% less) and higher lipid content (50% more). No significant inter-variety differences in proximate composition were observed except for lipid and fiber. The amount of crude fiber in Grafted-I tomato was found to be lower (8%) than the control while it was 22.67% higher in Grafted-II tomato. The calorie contents were found to be similar in all the tomato varieties.

Table 1. Compositional Analysis of Grafted and Nongrafted Tomatoes.

Tomato	Contents (g/100g)						
	Moisture	Protein	Lipid	Fiber	Ash	Carbohydrate	Energy (Kcal/100g)
Control	94.00±0.10	1.15±0.05	0.04±0.01	0.75±0.04	0.43±0.00	3.63±0.18	19.40±0.60
Grafted-I	94.30±0.20	1.43±0.31	0.06±0.01	0.69±0.11	0.44±0.02	3.13±0.54	19.00±0.90
Grafted-II	94.00±0.10	1.43±0.28	0.04±0.00	0.92±0.11	0.44±0.01	3.17±0.11	18.60±0.70

Values are mean ± SD. n=3.

(ii) Vitamins and minerals

The calcium and iron contents in Grafted-I tomato were significantly higher (56.67% for Ca and 28.99% for Fe) than the control. On the other hand, the sodium (35.05% less) and copper (33.33% less) contents in Graft-I tomato were lower than the control. Grafted-II tomato contained 27.66% less calcium, 23.59% less iron and 33.33% more copper than Grafted-I variety (Table 2). The ascorbic acid content in Grafted-II was found lower (11.85% less) while β–carotene content was appreciably higher (44.23% more) (Table 3). No significant differences in the contents of magnesium, zinc and potassium were found between the grafted and non-grafted tomatos.

Table 2. Mineral Content in Grafted and Nongrafted Tomatoes.

Tomato	Contents (mg/100 g)						
	Calcium	Magnesium	Sodium	Potassium	Iron	Zinc	Copper
Control	3.00 ± 0.4^{a}	7.10±0.20	1.94 ± 0.32^{a}	11.50±0.10	0.69 ± 0.09^{a}	0.28±0.01	0.09 ± 0.01^{a}
Grafted-I	4.70 ± 0.20^{b}	7.60±1.20	1.26 ± 0.10^{b}	11.60±0.10	0.89 ± 0.06^{b}	0.25±0.02	0.06 ± 0.00^{b}
Grafted-II	3.40 ± 0.10^{a}	7.50±0.20	1.17 ± 0.14^{b}	11.50±0.10	0.68 ± 0.05^{a}	0.25±0.01	0.08 ± 0.00^{a}

Values are mean ± SD. Values bearing unlike superscript letters are significantly ($p<0.05$) different. n=4.

Table 3. Ascorbic acid and β-Carotene Content in Grafted and Nongrafted Tomatoes.

Tomato	Contents (mg/100 g)	
	Ascorbic acid	β-Carotene
Control	27.00±1.30[a]	0.52±0.06[a]
Grafted-I	26.80±0.40[a]	0.51±0.15[a]
Grafted-II	23.80±0.70[b]	0.75±0.02[b]

Values are mean ±SD. Values bearing unlike superscript letters are significantly ($p<0.05$) different. n=4.

(iii) Antinutritional factors

The content of oxalic acid in Grafted-I tomato is 11.76% higher but statistically insignificant than the control and no significant inter-variety differences were observed. However, the phytic acid level was significantly lower in Grafted-I tomato (49.09% less) in association with a significantly higher tannin content (13.97% more) than the control (Table 4).

Table 4. Content of Antinutritional Factors in Grafted and Nongrafted Tomatoes.

Tomato	Contents (mg/100 g)		
	Phytic Acid	Oxalic	Tannin
Control	1.65±0.17[a]	3.40±0.50	35.80±1.40[a]
Grafted-I	0.84±0.12[b]	3.80±0.50	40.80±1.40[b]
Grafted-II	1.26±0.56[a]	4.20±0.30	40.00±2.50[b]

Values are mean ± SD. Values bearing unlike superscript letters are significantly ($p<0.05$) different. n=4.

Discussion

The present analysis assessed the quality of tomato grown over wild eggplant by a novel grafting technique. Analyses were carried out with regard to some nutritionally important classes of compounds present in tomato. Levels of some selected antinutritional components were also determined. The results obtained for control tomato were comparable with those previously reported

for tomato[9-13]; the present compositional analyses made on the grafted tomato, therefore, may be considered as reliable.

Based on the notion that novel cultivation technology-derived foods should be at least as safe and nutritious as traditional foods having a long history of safe use as a good source of nutrients. The concept of "substantial equivalence" was established and adapted to the quality assessment of novel cultivation technology-derived foods. "Substantial equivalence" implies a complete biochemical identity between the novel food and the existing food.

The tomato grown over wild eggplant by the grafting propagation method of Ali *et al.*,[1] differs from non-grafted control in the amounts of protein and several other nutritional components (Table 1, 2 & 3). The amount of protein in grafted tomato is about 1.24 fold higher than the control (Table 2). The higher level of protein may be due to better development phase in the grafting process because the grafting technique employed in the present study provided more resistance to diseases and thus a better development phase[1]. It has been reported that protein and nucleic acids undergo changes during cellular development of plant and the amount of protein increased during the total development phase[14]. The increase in the amount of protein and lipid contents in grafted tomato than the control, however, is statistically insignificant. Higher fiber content (1.33 fold more) in Grafted-II tomato than Grafted-I may be an expression of its genotype. The chemical composition, structure, and molecular weight of carbohydrates vary greatly depending on their botanical origin[14]. The fruit quality of grafted-II tomato variety was found harder and stout in appearance.

Of the minerals, the contents of calcium and iron were higher in Grafted-I variety while the contents of sodium and copper were lower. The increase or decrease in mineral contents in grafted tomato is difficult to explain. This may be a nonspecific effect of the grafting propagation method. However, the changes in mineral contents are all within the range of reported values of nongrafted tomato[9-13]. In the context of calcium and iron deficiency problems that prevails in the country, grafted tomato may help for increase the dietary intake of the minerals.

Presence of antinutrients in foods limits the nutritive value and thus quality of the food. Many hundreds of naturally occurring plant foods contain substances that are harmful and described as toxins, nutritional inhibitors, antinutrients, etc.[15]. Among the antinutrient factors studied for grafted tomato, oxalic acid content was found unaffected. Phytic acid level decreased substantially whereas tannin content increased (Table 4). Nevertheless, the change in antinutrients, specially increase in tannin content after grafting

propagation is far below the toxic level (acceptable tannin intake in human is 560 mg/day)[16] and seemed not to affect the heath of human beings.

Therefore, the nutritional quality and safety of grafted tomato may be guaranteed by "substantial equivalence" as presented in this analysis. And since grafting of tomato by the novel method of Ali *et al.*[1] resulted high yield and ensured early cultivation[2], the technique should be introduced through out the country in order to achieve maximum production.

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