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EFFECT OF GRAFTING RED TREE TOMATO (*CYPHOMANDRA BETACEA* SENDT.) ON SODA APPLE *(SOLONACEA ACULEASTRUM)* ON NUTRITIONAL VALUE OF FRUIT

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Abstract*- Grafting trees of similar botanical characteristics can produce a disease and environmental conditions resistant, and more productive plant. However, it is not known whether grafting affect the nutritional value of fruits. In the present study, the effect of grafting red tree tomato (Cyphomandra betacea Sendt.) on soda apple (Solanum aculeastrum) on nutritional value of fruit has been determined. The pH, titratable acidity, moisture, protein, fat, carbohydrates, ash, vitamin C, and mineral contents were determined using AOAC International approved Methods. Findings showed that there were no significant differences (P< 0.05) between parameters of grafted red tree tomato (GRTT) compared to no grafted red tree tomatoes (NGRTT). The pH values varied between 3.6±0.19 for GRTT and 3.8±0.27 for NGRTT. The titratable acidity ranged between 2.0±0.17 for GRTT and 1.8±0.10 for NGRTT. The moisture, protein, carbohydrates, fat, and ash contents ranged from 86.8±4.96, 2.0±0.20, 10.2±1.15, 1.2±0.06, and 0.84±0.04 for GRTT respectively; whereas the same values ranged from 87.1±3.66, 2.3±0.18, 10.7±1.91, 1.1±0.09, and 0.81±0.02 for NGRTT respectively. The vitamin C, phosphorus, magnesium, calcium, and iron contents varied from 22.0±1.73, 342.9±12.97, 60.2±5.03, 19.6±2.30, 9.2±1.45, and 0.45±0.03 for GRTT respectively; and the same values varied from 21.7±1.75, 345.6±13.36, 59.7±3.18, 19.9±2.70, 9.2±1.33, and 0.41±0.03 for NGRTT respectively. It is clear that grafting can be used to improve its production without affecting the nutritional value. Further research is required to study its protection potential against pest and diseases of tree tomato.

Keywords: Tree tomato, soda apple, grafting, scion, and rootstock.

I. INTRODUCTION

Grafting refers to joining a scion of the desired cultivar to a plant with an established root system, known as rootstock. The scion is expected to be high yielding variety, whereas the rootstock should be a long time yielding and disease resistant plant. Grafting is used by fruit growers to increase plant varieties, change the cultivar of a tree, or preserve a cultivar. Grafting is more effective and efficient method of reproduction for fruit trees than growing them from seeds. Major advantages of the present method include inducing desirable characteristics of the resulting plant, such as resistance to disease and pest, adaptability to local conditions, increasing plant vigor, and compatibility with the scion cultivar (Stoltz and Strang, 2005).

The tree tomato is a fruit tree that can reach the height of 20feet, usually lasting for 12 to 15 years. It produces a wide range of colors and sizes. It is a sub-tropical plant that grows better from 1000 to 10,000 feet of altitude. The tree tomato fruit is a source of a number of nutrients, such as proteins (1.5%), carbohydrates (10.3%), fat (0.06 to 1.28%), ash (0.61 to 0.84%), and fiber (1.4 to 4.2%).

Besides, 100g of tree tomato fruit contains phosphorous (52.5 to 65.5mg), ascorbic acid (23.3 to 33.9mg), calcium (3.9 to 11.3mg), fiber (1.4 to 4.2%), niacin (1.10 to 1.38mg/1), iron (0.66 to 0.94mg), carotene (0.371 to 0.653mg), and thiamine (0.038 to 0.137mg). Tree tomatoes are highly versatile for culinary use, such as tomato substitutes, cut fresh in salads, served sweetened in desserts, or added to spicy sauces (Romero- Rodriguez, et al., 1994; Amoo and Lajide , 1999)

The Soda Apple, *Solanum aculeastrum, sbsp. aculeastrum*, whose vernacular name " *Umutobotobo"*, occurs naturally in grassland, woodland and in forest margins, but also in disturbed places. In Southern Africa, it prefers a high rainfall of more than 700mm per year and it is found from 275-1780m altitude. It has been recorded from gentle to steep slopes and on all aspects, on various soil types, for examples sandy soils, reddish brown clay- loam and brown sandy loam. These species were reported as undesirable plants which should be reduced in number by appropriate yield management. It is listed as a component of the North- eastern Mountain Sourveld as reported by Acocks (1998).

Tree tomato plant is susceptible to a number of diseases that reduce the yield and yield life (Stoltz and Strang,

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2005;WHO,2011). In contrary, the soda apple is a disease and environmental conditions resistant plant and a long period productive plant (Acocks, 1998). To overcome problems related to growing tree tomato plant, the combination of both characteristics can produce a tree tomato variety that has improved characteristics than original one. This is possible due to belonging in the same family, solanaceae, reflecting their close botanical characteristics. Besides, this will extend the yielding period and indeed increase the productivity of the present plant. Thus, the aim of the present study carried out in the College of Agriculture, Animal Sciences and Veterinary Medecine (University of Rwanda), was to determine whether the technique of grafting red tree tomato (*Cyphomandra betacea* Sendt.) on soda apple *(Solonacea aculeastrum)* has an effect on nutritional value of tree tomato fruit.

II. MATERIALS AND METHODS

Fruit Materials

Mature fruits were collected to the plant resulting from grafting red tree tomato (*Cyphomandra betacea* Sendt.) on soda apple *(Solanum aculeastrum)* and the same tree tomato variety no grafted one, cultivated in the farm of the University of Rwanda, College of Agriculture, Animal Sciences and Veterinary Medicine, Busogo Campus.

Sample Preparation and Analysis

The 500g fruits were washed with distilled water, peeled, and were then homogenized for determination in triplicate of the following variables. The sample mean is the mean of these three determinations. Fruits were immediately taken to the laboratory of the same university for chemical analysis.

Fruit Juice

The 200g portion was used to make a juice for the determination of soluble-solids content of the present fruit juice according to AOAC Methods (1990). This is a physical method involving refractometry. The refractive index is converted via a set of tables into a degree Brix.

Homogenized Fresh Fruit

A mass of 500g of each sample was homogenized for determination in triplicate for the following variables. The sample mean is the mean of these three determinations. The determination of total nitrogen to provide an estimate of protein content was carried out by using Kjeldahl's method (AOAC, 1990). Ash contents of samples were determined according to AACC International Approved Methods 08-01.01 (2010) at 550^0C. The moisture content was determined according to the method proposed by AACC International Approved Methods (1983). Samples placed in the Forced Air Oven (Model 1350 FM, Sheldon Manufacturing Corp., Inc., IA, USA) and maintained at 105^0C for about 24h by spreading about 5g of sample on an aluminum dish until the weight was constant for 30min as measured by analytical balance (Model Scaltec, Sortorius Corp., NY, USA). Fat content was determined by Soxhlet extraction method using petroleum ether as proposed by AACC International Approved Methods (1986b). 100g fruit homogenate was dried and ground into flour using a pestle and a mortar to pass a sieve of 2mm openings. Sodium, potassium, calcium, magnesium, and iron were determined by spectrophotometric methods, as suggested by AOAC (1990).

III. STATISTICAL ANALYSIS

Data were analyzed using the SAS® package for Windows ®, 2002- 2008, version 9.2 (SAS Institute Inc. Cary, NC, USA) by performing the analysis of the least significant differences (LSD) by Duncan's Multiple Range Test. Differences were recorded when the analysis of variance (ANOVA) showed significant differences between data ($P< 0.05$).

IV. RESULTS AND DISCUSSION

pH and Total Acidity

The pH and total acidity of a food are important parameters to determine the safety, shelf life, and processing requirements of the product (USDA/ CFSAN, 2007). The acidity of a fruit is due to the content of several organic acids (citric, malic, acetic, ascorbic, galacturonic, etc.). It is relevant to keep the organoleptic nature inalterable and to avoid fermentation process. This makes the determination of this parameter important. The titratable acidity of fruit juice measures the concentration of titratable hydrogen ions contained in the fruit juice samples, by neutralization with strong base solution at fixed pH. This value includes all the substances of acidic nature in the fruit juice, such as free hydrogen ions, organic acids, acid salts and cations (Alamo et al., 1993).

The tree tomato juice contains citric and malic acids. The data on pH and total acidity of grafted versus no-grafted red tree tomato fruits are presented in the Table 1 below. The pH and titratable acidity values varied between 3.6±0.19 for GRTT and 3.8±0.27 for NGRTT. The titratable acidity varied between 2.2±0.17 for GRTT and 1.8±0.10 for NGRTT. There were no significant differences ($P<0.05$) in pH and total acidity values between the two kinds of fruits. Those values matched with those reported by Romero-Rodriguez et al, (1994), who mentioned that pH and total acidity of red tamarillo vary between 3.6±0.01 and 1.8±0.11 respectively.

Table 1. The pH and total acidity of grafted versus no-grafted red tree tomato fruits[a]

Parameter[b]	Amount (mg/100g)
pH	
GRTT	3.6±0.19a
NGRTT	3.8±0.27a
Total acidity	
GRTT	2.0±0.17a
NGRTT	1.8±0.10a

[a]Each value is expressed as mean ± standard deviation (n=3) of pH and total acidity values on dry weight basis (dwb). Mean values with different letters within a column for each kind of parameter are significantly different ($p< 0.05$).
[b]GRTT: Grafted red tree tomato, and NGRTT: No grafted red tree tomato.

Moisture, Protein, Total Sugars, Fat, and Ash Contents

Moisture, protein, carbohydrate, fat, and ash contents are the principle parameters measured to determine the nutritional quality of a food.

The moisture content is important to estimate the solid content of a food in reverse relationship. Finding on the present parameters are present in the Table 2. The moisture content of GRTT ranged from 86.8±4.96 versus 87.1±3.66 for NGTT. This is high moisture content as normal fruit at maturity. This high moisture in fruits can result in normal functioning of degrading enzymes and general metabolic processes resulting in rapid deterioration of fruits if left unprocessed for long time after harvesting (Umoh, 1998; Kohler and Bickoff, 1970).

Proteins are essential component of diet needed for survival of animals and human beings to supply adequate amounts of required amino acids for nutrition (Pugalenthal et al., 2004). Protein deficiency causes growth retardation, muscle wasting, edema, abnormal swelling of the belly and collection of fluids in the body (Perkins-Veazie, 2005). The protein concentration ranged from 2.0±0.20 for GRTT, and 2.3±0.18% for NGRTT, which lies in the same range as that reported by Romero- Rodriguez et al. (1994).

The carbohydrates are essential to provide energy to humans. Samples with low carbohydrate content might be ideal for diabetic and hypertensive patients requiring low sugar diets (Adaunwo et al. 2013). The carbohydrate content ranged from 10.2±1.15% for GRTT and 10.7±1.91% for NGRTT, which match with the literature (Romero- Rodriguez et al., 1994).

Fat is important in diet to provide energy in human body, smooth and fill in cellular structures. In food, fat provides flavor, but can be a cause of spoilage when present in significant amount. Fat is in small amount in fruits. In the present study, fat content ranged from 1.2±0.06 and 1.1±0.09% for GRTT and NGRTT respectively. This is a normal range of fat content of tree tomato fruit (Adaunwo, et al., 2013).

The ash content of the sample gives an idea about the inorganic content of the samples from where the mineral content could be obtained. Samples with high percentages of ash contents are expected to have high concentrations of various mineral elements, which are expected to speed up metabolic processes and improve growth and development (Brain, 1992; Amono and Lajide, 1999). The ash content of these fruits ranged from 0.84±0.04% for GRTT and 0.81±0.02% for NGRTT, which match with the literature (Romero- Rodriguez et al., 1994)

Vitamin C and Mineral Contents

The vitamin C and mineral compositions of the fruits' samples were reported in Table 3. Vitamin C, also known as ascorbic acid, is an important nutrient because of its antioxidant and therapeutic properties. It helps the body in forming connective tissues, bones, teeth, blood vessels and prevents tissue damage (Xu et al., 1996). Vitamin C is used to treat a number of diseases, such as scurvy, anemia, hemorrhagic disorders, wound healing as well as infertility (Basu and Dickerson, 1996). Most plants and animals have the ability to synthesize vitamin C. However, humans do not synthesize vitamin C, and therefore depend on exogenous sources of the vitamin which include fruits and vegetables as well as food supplements and pharmaceutical preparations (Okiei et al., 2009). Levels of Vitamin C ranged from 22.0±1.73 and 21.7±1.75mg/100g respectively for GRTT and NGRTT. These values were in the normal range of a fruit (Okiei et al., 2009).

Table 2. Moisture, protein, fat, total sugar, and ash contents of grafted versus no- grafted red tree tomato fruits[a]

Parameter[b]	Amount (%)
Moisture	
GRTT	86.8±4.96a
NGRTT	87.1±3.66a
Proteins	
GRTT	2.0±0.20a
NGRTT	2.3±0.18a
Carbohydrates	
GRTT	10.2±1.15a
NGRTT	10.7±1.91a
Fat	
GRTT	1.2±0.06a
NGRTT	1.1±0.09a
Ash	
GRTT	0.84±0.04a
NGRTT	0.81±0.02a

[a]Each value is expressed as mean ± standard deviation (n=3) of moisture, proteins, carbohydrates, and fat values on dry weight basis (dwb). Mean values with different letters within a column for each kind of parameter are significantly different ($p< 0.05$).

[b]GRTT: Grafted red tree tomato, and NGRTT: No grafted red tree tomato.

Minerals are important for different functions in human body. Human body requires them in very small amounts, and dietary minerals are considered micronutrients. All minerals needed for health are essential nutrients because the body cannot make them from other compounds. Thus, humans rely on the diet to get these important nutrients (McGuire and Beerman, 2011).

Magnesium is used to prevent muscle cramping and it enhances nerve functioning, reduces tight sore muscle and improve bone density. Magnesium plays a major role in relaxing muscles along the airway to the lung thus allowing asthma patients to breathe easier. Deficiency of magnesium in man is responsible for severe diarrhea, migraines, hyper-tension, cardiomyopathy, arteriosclerosis and stroke (Bello et al., 2008).

Because phosphorus (P) is a component of the phospholipid bilayers that make up all cell membranes, it has both structural and functional roles in your human body. For example, it is important for skeletal health, enzyme activation, and energy metabolism.

Potassium is the most abundant cation in intracellular fluids. Potassium helps to lower blood pressure. It is a critical electrolyte, being important for fluid balance and a variety of other physiologic functions.

Calcium is needed in bone and tooth health, blood health, energy metabolism, fluid balance, and nerve and muscle function.

Iron (Fe) is required for energy and endurance because it delivers oxygen throughout the body. Iron is said to be an important element in the diet of pregnant women, nursing mothers, infants, convulsing patients and elderly people to prevent anaemia and other related diseases (Oluyemi et al. 2006).

In the present research, potassium has been the most abundant mineral found in the fruits followed by K > P > Mg > Ca > Fe respectively. The levels of potassium, phosphorous, magnesium, calcium, and iron ranged from 342.9±12.97, 60.2±5.03, 19.6±2.30, 9.2±1.45, and 0.45±0.03mg/100g respectively for GRTT. The same parameters ranged from 345.6±13.36, 59.7±3.18, 19.9±2.70, 9.2±1.33, and 0.41±0.03mg/100g. These ranges were similar to those reported by the work of Adaunwo et al. (2013).

Table 3. Vitamin C and mineral contents grafted versus no- grafted red tree tomato fruits[a]

Parameter	Amount (mg/100g)
Ascorbic acid	
GRTT	22.0±1.73a
NGRTT	21.7±1.75a
Potassium	
GRTT	342.9±12.97a
NGRTT	345.6±13.36a
Phosphorous	
GRTT	60.2±5.03a
NGRTT	59.7±3.18a
Magnesium	
GRTT	19.6±2.3a
NGRTT	19.9±2.7a
Calcium	
GRTT	9.2±1.45a
NGRTT	9.2±1.33a
Iron	
GRTT	0.45±0.03a
NGRTT	0.41±0.03a

[a]Each value is expressed as mean ± standard deviation (n=3) of ascorbic acid, and minerals values on dry weight basis (dwb). Mean values with different letters within a column for each kind of parameter are significantly different ($p< 0.05$).
[b]GRTT: Grafted red tree tomato, and NGRTT: No grafted red tree tomato.

V. CONCLUSION

Tree tomato is threatened by a number of diseases that reduces its productivity. The present study was aimed at determining the effect of grafting red tree tomato (*Cyphomandra betacea* Sendt.) on soda apple *(Solanum aculeastrum)* on nutritional value of fruit. There were no significant differences in all determined parameters ($P< 0.05$) between GRTT versus NGRTT. The moisture, protein, carbohydrate, fat, ash, vitamins C, and mineral contents of GRTT were in normal ranges of tree tomato fruits. It can be concluded that grafting can be used to improve its production without affecting the nutritional value of fruit. Further research is required to study its protection potential against diseases and pests of tree tomato.

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