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Some fruit quality characteristics of 'Grand Naine' banana fruits during various ripening stages

Ömer Faruk BİLGİN*[1] Gözde NOGAY[1] Nesibe Ebru KAFKAS[1] Salih KAFKAS[1]

[1]University of Çukurova, Faculty of Agriculture, Department of Horticulture, Adana, Turkey.
***Correspondence:** ofarukbilgin35@gmail.com

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Abstract

During ripening and ageing, the chemical components and antioxidant capabilities of bananas alter dramatically. The effects of different ripening stages (green, ripen and over ripe) of the flesh of banana cultivar 'Grand Naine' on the total phenolic substance, antioxidant capacity of banana flesh, total sugar, sucrose , fructose , and glucose content were investigated. The total phenolic content was found to be 10.54 mg GAE /100g in the green (first stage) banana, 9.03 mg GAE /100g in the medium ripe banana (fourth stage) and 13.46 mg GAE /100g in the over ripe (seventh stage) banana. When comparing the antioxidant contents, the highest DPPH (%) radical scavenging value was obtained from the fruits of the fully ripe (seventh stage) banana (51.64%), while the lowest %DPPH radical scavenging value was obtained from the fruits of the fully ripe (seventh stage) banana (17.06%). In the Frap assey, the overripe banana had the highest content of Trolox equivalents (TE), 1.24 mg TE / g FW, followed by the medium ripe (0.63 mg TE / g FW) and the green banana (0.56 mg TE / g FW). The HPLC sugar profiles displayed that sucrose is the most important sugar, followed by fructose and glucose in all ripening stages of banana fruit pulp samples. The content of soluble sugars (sucrose, glucose and fructose) in the 'Grand Naine' banana increased during the fruit ripening stages. 'Grand Naine' showed increasing sugar content as ripening progressed and was highest when the fruit was fully ripe.

Key words

Total Phenol Content, Dpph Scavenging Activity, Solubla Sugar Content, Banana, sugars, HPLC.

Introduction

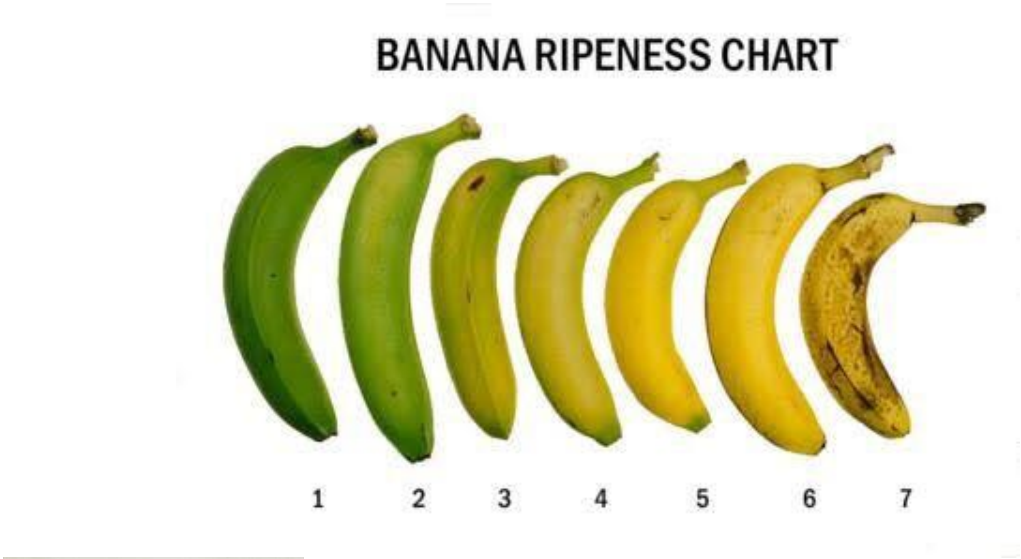
The banana (*Musa cavendishii* L.) cultivated as a fruit, belongs to the Musaceae family of the order Scitamineae. The Musaceae family has two major genera, Musa and Ensete. The genus Musa includes the edible cultivated species and Esnete, the wild species found in the forests of East Africa. There are 4 subgenera within the genus Musa. These are Australimusa, Eumusa, Callimusa, and Rhodochlamys. Among these subgenera, Australimusa and Eumusa are important species. The species of Callimusa and Rhodochlamys are used as ornamentals. The most important Australimusa species is *Musa textilis*, from which fibers called Manila hemp are obtained and used in the textile industry world trade today (Kuchi et al., 2017) . It is native to southern China, India, and the islands between India and Australia. In our country, it was first introduced in the middle of the 18th century. It was brought to Alanya from Egypt as an ornamental plant, and when it was realised that its fruits could also be eaten, it was brought to Anamur and cultivated in 1935 (Akova, 1997) . Banana cultivation is carried out worldwide under tropical conditions in countries such as India, Ecuador, Brazil, the Philippines, Indonesia and Costa Rica, and under subtropical climatic conditions in countries such as Egypt, Spain, South Africa, Lebanon, Portugal, Jordan, Israel and Turkey. In our country, banana cultivation was carried out under greenhouse conditions in Anamur and Bozyazı locations in Mersin province and in Alanya and Gazipaşa locations in Antalya provinces of the Mediterranean region in limited areas called microclimate areas until a few years ago, and in Anamur and Bozyazı, which belong to these areas. On the other hand, it is mostly grown in the open-field conditionss in Alanya and Gazipaşa (Gubbuk et al., 2017). The latitude and longitude of our country are far outside the banana growing areas of the world. Nevertheless, banana is the most important economically cultivated species among tropical fruits in our country. In recent years, in terms of cultivated areas, especially in the Mediterranean region, outside the microclimate areas, it has been noted that greenhouse cultivation has greatly increased and this expansion is moving towards the Aegean region. Banana is one of the most favorite fruits in the global market (Meechaona et al., 2007). This tropical fruit can fight oxidative stress caused by harsh sunshine and high temperatures by increasing its antioxidant content. Several studies have shown that both the banana pulp and peel contain antioxidants such as vitamins, B-carotene, phenolic compounds (catechin and epicatechin), lignin, and tannins, as well as anthocyanins (Lim et al., 2007; Someya et al., 2002; Wall, 2006). Bananas are also rich in potassium and phosphorus (Hardisson et al., 2001; Leterme et al., 2006; Wall, 2006). There is augmenting evidence that banana peels have higher groups of phenolic constituents and antioxidant attributes than fruit. (Kondo et al., 2005; Someya et al., 2002) and minerals than banana pulp (Emaga et al., 2007; Forster et al., 2002). However, most of the aforementioned studies have focused on a single variety, which is the best known banana variety, namely Musa acuminata AAA (Cavendish subgroup) (González-Montelongo, Lobo, et al., 2010; Someya et al., 2002; Vijayakumar et al., 2008).

The aim of this study was (i) to compare the antioxidant activity, total phenolic content, and soluble sugar content of banana cultivar 'Grand Naine' at different stages of ripening under greenhouse conditions in the Mersin region.

MATERIALS AND METHODS

Materials

The plants of 'Grand Naine' banana variety grown under greenhouse condition in Kazanlı region of Mersin provinces in Turkey was used as material. The fruits harvested in the three stages as mentioned in Figure 1 and were analyzed first stage, fourth stage, seventh stage



1) Firstly Stage

2) Fourth Stage

3)Seventh Stage

Method

The fruits harvested from the greenhouse were immediately taken to the Enstrumental Analysis Laboratory at Çukurova University, Agriculture Faculty, Horticulture Department. The fruits peeled and fruit pulp were homogenized and stored at -20 ºC until analysis. The analyzes of total phenolics and antioxidant activity and individual sugars were performed in 3 replicates using a spectrophotometer and HPLC (High Performance Liquid Chromatography), respectively.

Total phenol

After the fruit samples were homogenized and weighed, the determination of total phenols of banana samples of different ripening stages was carried out by modifying the spectrophotometric method of Spanos & Wrolstad, (1990) . The metrical values were computed from the absorbance value at a wavelength of 760 nm in the spectrophotometer (MultiskanTM GO microplate spectrophotometer) and the calibration curve developed with gallic acid. Results were represented as mg gallic acid equivalent/100 g weight (mg/ GAE 100 g).

DPPH Scavenging Activity(%)

Total antioxidant capacity was determined from the reducing antioxidant power of iron (FRAP) in according to Benzie & Strain, (1996) method and DPPH described by (Okatan et al.,(2021) . The antioxidant capacity of banana pulp samples at different ripening stages was investigated by evaluating the radical scavenging effect on the DPPH (1,1-diphenyl-2-picrylhydrazyl radical). The result was determined according to a procedure described by Sultana et al. (2008) with slight modifications. Briefly, 5.0 ml of a freshly prepared DPPH (methanolic 1,1-diphenyl-2-picrylhydrazyl) solution at a concentration of 0.025 g/l added to 1.0 ml of an extract having 25 µg/ml dry weight in methanol. The mix was vibrated, held in the dark, and let to stand at room temperature for 2 hours. The absorbance of the consequent solution was estimated at 515 nm using a UV spectrophotometer (Shimadzu UV-1601PC, Tokyo, Japan) and likened to a blank sample of methanol without DPPH. The outcomes were represented as the ratio of inhibition of the DPPH radical and computed according to the subsequent equation:

DPPH -Percentage % of reduction power =($\frac{Ac-As}{Ac}$**)**x100

Ac : control

As : sample

Ab : Blank

For the extraction of the reducing antioxidant power of iron (FRAP), 1 g of the frozen banana pieces was put in an aluminum foil-wrapped flask including 50 mL of an 80% methanol solution. The flasks were shaken in an incubator at 30°C and 150 rpm for 24 hours. The samples were centrifuged at 3200 rpm for 20 minutes and the supernatant was gathered. For the FRAP method, 100 uL of the extract was blended with 2.9 mL of FRAP reagent including 30 mM acetate buffer, pH 3.6, 10 mM TPTZ (2,4,6-tripyridyl-s-triazine) in 40 µM HCl and 20 mM FeCl3 at a ratio of 10:1:1 (v/v/v)) and vortexed. Samplings were set in a water bath (ST30, Nueve, Turkey) for half of an hour at 37°C, and absorbance was determined at 593 nm. Values were represented as millimoles TE mg /g-1 iron equivalent Fe (II) per gram of banana samples.

Sugar Analysis

Using Valero et al., (2007) method modifieded by Kilic et al.,(2021) and Urün et al., (2021), the total amount of sugar, fructose composition, and sucrose composition (mg per 100 g fresh weight) in banana fruit at various stages of maturity were examined. Prior to analysis, the peeled banana samples were ground. 1 g of the banana samples was put to 4 mL of ultrapure water (Millipore Corp., Bedford, MA, USA). The reaction mixture was set in an ultrasonic bath and sonicated at 75-80 C for 15 min. It was then centrifuged at 5500 rpm for 15 minutes and purified (Whatman nylon syringe filter, 0.45 µm, 13 mm diameter) before HPLC analysis. The HPLC instrument (Shimadzu LC 20A high performance liquid chromatography instrument VP, Kyoto, Japan) includes an inline degasser, pump, and controller, as well as a refractive index detector (Shimadzu RID 20A VP, Kyoto, Japan) with an automatic injector (20 L injection volume) that is connected to a PC running Class VP Chromatography Manager software (Shimadzu, Kyoto, Japan). Splits were performed at 70 °C with a flow rate of 0.6 ml min-1 on a 300 mm 7.8 mm i.d., 5 m reversed-phase Ultrasphere Coregel-87 C analytical column (Transgenomic). With ultrapure water, elution was isocratic. Total sugar,

fructose, and sucrose concentrations were calculated using respective standards and expressed as a percentage of fresh weight (FW).

Statistical Analysis

The trial had three replicates and was completely randomized. The statistical analyses were carried out using the SAS Institute's JMP statistical program 22.0.0 (1 (North Carolina, USA).) The data were subjected to analysis of variance, and Duncan's multiple range test was used to separate the means at a significance level of 0.05.

Results and Discussion

Phenols are crucial healthy components of fruits as they have antioxidant effects by inactivating free lipid radicals or controlling the decompositon of hydroperoxides to free radicals (Maisuthisakul et al., 2007) As a result of this study, it was found that the percentage DPPH radical scavenging and total phenolic content of banana samples (mg/ GAE 100 g) have changed in different ripening periods. In addition, the statistical differences in the results of TPC and DPPH radical scavenging activities ($P < 0.05$) between banana samples were found to be significant ($P < 0.05$). Total phenol was found to be 10.54 mg GAE /100g in green banana (first stage), 9.03 mg GAE /100g in medium ripe (fourth stage) banana and 13.46 mg GAE /100g (seventh stage) in over ripe banana. When antioxidant contents were compared, the highest %DPPH radical scavenging value was found in the fruit of the ripe banana (51.64%), while the lowest %DPPH radical scavenging value was found in the fruit of the medium ripe banana (17.06%). The determination of the efficiency of antioxidant compounds is generally used FRAP methods in plants that compete with the reagent FRAP and reduce the ferric to ferrous iron. Antioxidant compounds that can act in this method are classified as secondary antioxidants because they repress the formation of radicals and control oxidative damage. In addition, secondary antioxidants also have the function of metal chelators and oxygen scavengers. Decreasing the iron content(III) leads to the formation of a blue coloured product, ferrous-TPTZ(2,4,6-tris(2-pyridyl)-s-triazine) complex in the reagent FRAP. In our study, it was found that the highest content of Trolox equivalents (TE) in the overripe banana (1.24 mg TE / g FW), followed by the medium ripe (0.63 mg TE / g FW) and green banana (0.56 mg TE / g FW) in FRAP experiment (Table 1).

In the FRAP method, the chloroform extraction method yielded the highest activity in the dried pulps of the Awak and Berangan banana varieties and the dried peels of the Rastali variety. The values were 22.57±0.13 (Awak variety), 22.53±0.12 (Berangan variety), and 21.63±0.42 mg TE /g d.w (Rastali variety) (Sulaiman et al., 2011). Besides, Alothman et al., (2009) found that mas banana variety includes 0.59-3.30 µmol ferum (II) /g FW in FRAP method. Authours also found that the highest content of trolox equivalents (TE) in the raja banana variety namely 0,140.8-0,1607 g TE /100 g FW, followed by mas (233.6-485.8 mg TE /100 g FW) and Beranganese (39.4-403.7 mg TE /100 g FW), which depending on the types of solvent used (Shian & Abdullah, 2012). Different extraction procedures and solvents may have resulted in different outcomes (Chirinos et al., 2007). In our study, we also found that the changes in total antioxidant content were well related to the changes in antioxidant activities. We determined that green bananas have lower total phenolic content than over ripe fruits. Fatemeh et al., (2012) also showed that green bananas have lower total phenolic content than ripen fruits The extracts' radical scavenging abilities (DPPH inhibition) ranged from 26.55 to 52.66 percent (first stage to seventh stage). González-Montelongo et al., (2010) compared different solvents for their DPPH scavenging activity. They revealed that acetone:water extracts had the highest antioxidant activity compared to the other solvents studied, with a factor of 1.3-1.9 (methanol) and 25-35 (acetone) for the DPPH assay and a factor of 2-4 (methanol) and about 10-35 (ethanol, acetone, and water in the banana variety "Grande Naine" and ethanol, acetone, and water in "Gruesa") for the the ABTS+ assay. The extracts produced with acetone:water have greater radical scavenging activity than 1.8 g TE or AE /100 g freeze-dried residue powder. Although ethanolic extracts inhibited DPPH more than acetone extracts (by 4.5 to 5.5 times), their actions against ABTS+ radicals were quite similar. In another study, Fernando et al., (2014) investigated the changes in total phenolic content in banana cultivar 'Khai' during storage. They found that it decreased in the first two days of storage and then significantly increased until the 6th day of storage. Total antioxidant activity increased with ripening and decreased rapidly with senescence in the banana cultivars studied. Ngoh Newilah et al., (2008) documented similar results in hybrid bananas, where phenolic content increased during ripening before decreasing at the fully ripe stage. The results of our study are comparable to values reported in the literature. In our study, we also found that the changes in total antioxidant content were well related to the changes in antioxidant activities. A direct relationship was also found in other fruits (Baskar et al., 2011; Patthamakanokporn et al., 2008; Sulaiman et al., 2011).

Table 1. At different stages of ripeness, total phenolic content (mg/ GAE 100g) and DPPH radical scavenging values percent of banana samples (mean SD,n=3)

	Total Phenol	DPPH radical scavenging%	Frap
Green (First Stage)	10.54±1.57b	45.25±1.68b	0.56±0.01c
Medium Ripe (Fourth Stage)	9.03±3.67b	17.06±0.75c	0.63±0.01b
Over Ripe Banana (Seventh Stage)	13.46±1.42a	51.64±0.97a	1.24±0.06a

The HPLC sugar profiles show that sucrose is the major sugar, followed by fructose and glucose in all banana samples (Table 2). The content of soluble sugars (sucrose, glucose and fructose) in the 'Grand Naine' banana increased with fruit ripening (Table 2). 'Grand Naine' showed increasing sugar content as ripening progressed, being highest when the fruit was fully ripe. Fernando et al., (2014) reported that in the Khai banana cultivar, sugar content increased as ripening progressed and was highest after 8 days of storage. They also reported the sugar content leveled off two days later when the fruits were overripe. In contrast, sugar content of the Hom Thong banana cultivar increased during the first 4 days of storage. During ripening, the Hom Thong banana cultivar showed the same characteristics as the Grand Nine variety during the ripening process. The increase in sugar content is a typical characteristic of ripening bananas due to the increased conversion of starch to sugar (Valerio-Traya et al., 2002). Cordenunsi & Lajolo, (1995) also noticed a significant drop in starch content, which was accompanied by a rise in sugar content. In our study, fructose concentration was lowest and sucrose content was highest during the green and medium ripening stages, implying that sucrose dominates over glucose and fructose as the peel matures. (Soares et al., 2011). On the other hand, the differences between the contents of glycose, fructose and sucrose are very small at the stage of full maturity.

Table 2. Shows the results of free sugars in banana samples (mg per 100 g fresh weight) (mean SD, n=3).

	Free Sugar			Total Sugars
	Sucrose	Glucose	Fructose	
Green (First Stage)	1341.6±70,4^{a}	21.73±0,2^{b}	13.06±1,4^{c}	1375±71.6^{b}
Medium Ripe (Fourth Stage)	408,6±4,32^{a}	165.84±15,55^{b}	84.6±7.49^{c}	667±18.71^{c}
Over Ripe Banana (Seventh Stage)	2444.07±55.44^{a}	2189.22±68,7^{a}	2578.58±7.67^{a}	7220±131.82^{a}

Conclusions

The following are some of the study's findings:

- Total phenolic content and DPPH scavenging activity decrease with medium ripe and then decrease when fruits are overripe.
- The content of soluble sugars (glucose, fructose) increased with ripening.
- When the fruit ripens, the content of glucose, and total sugars increases sharply.

– HPLC profile provides valuable information on sugar composition and fruit quality to evaluate the influence of technological processes.

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Statement of Conflict of Interest
The author(s) declare no conflict of interest for this study.

Author's Contributions
The contribution of the authors is equal

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