Türk Tarım ve Doğa Bilimleri Dergisi 8(4): 928–933, 2021

https://doi.org/10.30910/turkjans.870796

TÜRK
TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TTDB

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.dergipark.gov.tr/turkjans

Research Article

Kültür Kiraz Çeşitlerin Bazı Fitokimyasal Özellikleri ve Bu Özellikler Arasındaki İlişkiler

Kerem MERTOĞLU*

Eskişehir Osmangazi Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, Eskişehir
*Sorumlu Yazar: kmertoglu@ogu.edu.tr

Received: 29.01.2021 Received in revised: 07.10.2021 Accepted: 13.10.2021

Öz

Bu çalışma, bazı kiraz çeşitlerini (0900 Ziraat, Regine, Kordia, Sweetheart, Starks Gold ve Early Burlat), Eskişehir ekolojik koşullarında, fitokimyasal özellikler bakımından karakterize etmek amacı ile yürütülmüştür. Araştırma sonucunda, C vitamini, toplam fenol, antioksidan aktivite, suda çözünebilir kuru madde (SÇKM) ve pH özellikleri bakımından, kiraz çeşitleri arasında önemli varyasyonlar olduğu ve değerlerinin sırası ile 2.53 (0900 Ziraat) – 4.43 (Kordia) mg 100 mL^{-}, 186.10 (0900 Ziraat) – 260.63 (Sweetheart) mg L^{-}, %37.56 (0900 Ziraat) – %57.13 (Sweetheart), %13.17 (Starksgold) – %19.26 (Regina) ve 3.52 (Kordia) ile 4.00 (Early Burlat) aralıklarında değişim gösterdiği tespit edilmiştir. Korelasyon analizleri sonucunda, pH'nın düşmesi ile C vitamini, toplam fenol ve antioksidan aktivitenin arttığı ve toplam fenol ile antioksidan aktivite arasında yüksek düzeyde pozitif ilişkinin (r = 0.92***) olduğu sonucuna varılmıştır.

Anahtar kelimeler: *Prunus avium*, C vitamini, Toplam fenol

Some Phytochemical Characteristics of Cherry Cultivars and Relations Between These Characteristics

Abstract

This study was carried out to characterize some cherry cultivars ('0900 Ziraat', 'Regina', 'Kordia', 'Sweetheart', 'Starks Gold' and 'Early Burlat') in terms of phytochemical characteristics in Eskisehir ecological conditions. As a result of the research, vitamin C, total phenol, antioxidant activity, soluble solid content (SSC) and pH were showed high variation among cherry cultivars and values were determined in the range of 2.53 (0900 Ziraat) – 4.43 (Kordia) mg 100 mL^{-}, 186.10 (0900 Ziraat) – 260.63 (Sweetheart) mg L^{-}, %37.56 (0900 Ziraat) – %57.13 (Sweetheart), %13.17 (Starksgold) – %19.26 (Regina) and 3.52 (Kordia) - 4.00, respectively. According to correlation analysis, it was concluded that vitamin C, total phenol and antioxidant activity increased with decreasing pH and there was a high positive correlation (r = 0.92***) between total phenol and antioxidant activity.

Key words: *Prunus avium*, vitamin C, Total phenol

Introduction

Chemical properties, which are one of the most important factors affecting taste formation in herbal products, are also important in terms of affecting the qualitative and quantitative quality parameters of both fresh fruits and processed products.

Humanity, whose awareness level has increased, tends to products with rich and diverse biochemical content (Demir & Aktaş, 2018). Hence, it is stated that these products are rich in organic and phenolic acids with high antioxidant effects and these compounds prevent oxidation and peroxidation reactions. It is stated that this antioxidative effect reduces the risk of many chronic diseases (Tang & Tsao, 2017; Pham et al., 2019). Considering the consumer trend, it has become important for plant breeders recently to improve the phytochemical composition in breeding genotypes with superior characteristics.

For this reason, studies are primarily conducted on the phytochemical compositions of existing genetic resources (Polat et al., 2018; Gundogdu et al., 2018; Çavuşoğlu et al., 2018; Karaat et al., 2019; Acero et al., 2019; Okatan, 2020). New genotypes are developed by using parents with superior qualities in terms of desired properties in classical and modern breeding methods (Cevallos-Casals et al., 2006; Ramirez-Ambrosi et al., 2015; Yazici and Şahin, 2016; Sahoo et al., 2017).

Being a functional species, cherry is a fruit with high demand and price due to the fact that it is evaluated in many different ways as an industrial product as well as it is consumed fresh and dried (Florkowski & Lysiak, 2015). Within the scope of this study, six different cherry cultivars, which are cultivated extensively, has been characterized in Eskişehir ecological conditions in terms of some phytochemical properties. In addition, as a result of the correlation analysis between the features, it has been determined which features have the potential to be taken together.

Material and Method

Six different cherry cultivars namely; '0900 Ziraat', 'Regina', 'Kordia', 'Sweetheart', 'Starks Gold' and 'Early Burlat' were used as a plant material. Cultivars were planted in 2011 after grafting onto Ma×Ma rootstock. Study material is located in Eskişehir-Central region in where typical continental climate is seen. Climatic parameters of research area in related months is given in Table 1.

Table 1. Climatic data of research area (Meteorology 3. District Management – Eskişehir, 2020)

	Precipitation (mm)		Humidity (%)		Temperature (^oC)	
	2017	**Long term**	**2017**	**Long term**	**2017**	**Long term**
March	16.2	30.3	68.7	65.1	7.6	5.3
April	62.0	40.5	66.9	62.8	9.6	9.9
May	50.8	41.9	73.2	60.8	14.4	14.8
June	44.8	29.9	73.4	57.2	19.1	18.9
July	13.4	14.2	59.5	53.0	23.1	21.9
August	31.4	12.42	67.3	54.7	22.0	21.8
September	2.6	16.98	57.0	58.4	19.6	17.3

In the harvesting of cherry fruits, coloring and taste were considered as harvest criteria (Romano et al., 2006). After the fruits of each tree were harvested without mixing with the others, they were turned into fruit juice by a juice extractor and these juices were used in phytochemical analysis.

The amount of soluble solid content (SSC) was measured with a digital refractometer (Atago PR-32, Japan) and the results were given as a percentage (%) (Karaçalı, 2012). The volumetric titration method was used to determine the amount of vitamin C. According to the method, starch was used as an indicator and titrated with potassium iodide. Calculations were made in line with the formula stated by Mertoğlu and Evrenosoğlu (2019) and the results were given as mg 100 mL^{-1}. Fruit juices were firstly centrifuged for total phenol and antioxidant activity analysis. In determining the total phenol amount, the Folin-Ciocalteu method was conducted as Selcuk and Erkan (2016) indicated. In the preparation of the standard curve, gallic acid was used and the results were expressed as mg GAE L^{-1}. Antioxidant activity analyses were carried out using the DPPH method. For this purpose, in the first step, all the fruit juices were mixed and the ability of this mixed juice to remove DPPH radical in different concentrations was identified, and the sample concentration (IC50) providing 50% inhibition was determined. Then, the ability to remove DPPH radicals was determined according to the method specified by Polat et al. (2008) by taking samples separately from each cultivar as much as IC50 value determined, and the results were expressed as a percentage (%).

The research was conducted with three replications and each replication contains three parallel according to the randomized block experimental design in 2017. Whether the properties examined show statistically significant differences between the cultivars was determined using the one-way ANOVA procedure in the Minitab-17 package program. Tukey multiple comparison test was used to reveal the differences between cultivars. Correlation analysis was utilized to determine the relationships between features (Zar, 2013).

Results and Discussion

The distribution of the investigated chemical properties in the study according to the

cultivars is given in Table 2. In line with the results, it was determined that all the properties examined showed significant differences between cultivars.

Table 2. Results of investigated phytochemical properties in according to cultivars

	SSC (%)	pH	Vitamin C (mg 100 mL^{-})	Total Phenol (mg GAE L^{-})	Antioxidant activity (%)
Early Burlat	14.91c	**4.00a**	3.63b	186.11b	37.57c
Kordia	16.43b	**3.52d**	**4.43a**	260.07a	57.01a
Starks Gold	**13.17d**	3.94a	2.97bc	213.87ab	45.91bc
0900 Ziraat	16.48b	3.55cd	**2.53c**	**186.10b**	**37.56c**
Regina	**19.26a**	3.64c	3.07bc	244.10a	53.63ab
Sweetheart	16.54b	3.74b	3.27b	**260.63a**	**57.13a**
ANOVA	***	***	**	**	***

SSC: Soluble solid content. Differences between the averages shown with different letters in each column are statistically significant (**: P <0.01, ***: P <0.001)

The highest value in terms of soluble solid content was found in 'Regina', while Starks Gold (13.17%) with white fruit skin and flesh colour and Early Burlat (14.91%) which is an early cultivar were found to have the lowest value in terms of this feature. In studies conducted with of different species, it has been reported that phytochemical accumulation is lower in early cultivars with a shorter period from full bloom to harvest and in the cultivars with lighter fruit flesh and skin color (Eskimez et al., 2020; Polat et al., 2020a). Conversely, as duration of remaining on the branch of the fruit increases, organic acids, which have a lower degradation coefficient in respiration than other compounds, are primarily used as breakdown products in metabolic events. For this reason, pH in early cultivars is generally higher than the others. The results of the study were found in parallel with this situation and the highest pH value was measured in Early Burlat with 4.0. On the other hand, Kordia was found to have the lowest pH value with 3.52.

The lowest values in terms of total phenol and vitamin C content were found in the 0900 Ziraat and were determined as 2.53 mg 100 mL^{-} and 186.10 mg GAE L^{-}, respectively. The low levels of these compounds with high antioxidant effects in 0900 Ziraat caused the antioxidant activity (37.56%) of this type to be at the lowest level among the studied cultivars. While the total phenol amount was determined as the highest in Sweetheart with 260.63 mg GAE L^{-}, a similar result was obtained from Kordia 4.43 mg 100 mL^{-} for vitamin C. There was no statistically significant difference between these two cultivars in terms of antioxidant activity, and it was determined that they form the upper group with 57.13% (Sweetheart) and 57.01% (Kordia) values.

In similar studies conducted with different cherry cultivars, change interval for soluble solid content was reported between %15.0 – 16.1 (Saracoglu et al., 2017); %17.7 - 24.5 (Ouaabou et al., 2020); %11.9 – 23.87 (Gonçalves et al., 2020). Similar notifications were made for total phenol content in the range of 373.7 - 798.7 mgGAE L^{-1} (Göksel and Aksoy, 2014); 588.5 – 644.8 (Çavuşoğlu et al., 2018). Vitamin C changed from 6.01 to 1.44 (Gundogdu and Bilge, 2012) and from 1.9 to 9.2 (Sirbu et al., 2018). Antioxidant activity obtained by DPPH method is varied within the limits of 29.88 – 86.94% (Prvulovic et al., 2011); 13.0 – 90.0% (Skrzynski et al., 2016) and and pH value is in the range of 3.37 – 4.03 (Karaat et al., 2019); 3.68 – 4.52 (Eroğul, 2016).

It is determined that obtained results are largely in line with previous studies. Although the differences are thought to be mainly caused by the variation of the examined varieties, differences in climate and soil characteristics, the geographical situation of the area where the cultivation is made, the type and time of harvest, the storage or processing of the crop, the method or periodic differences of the applied cultural processes cause significant differences on the final form of the phytochemical composition (Tiwari and Cummins, 2013; Polat et al., 2020a). Changes in phytochemical properties in parallel with the change of ecological factors and growing conditions were reported (Mertoğlu et al., 2020).

Table 3. Correlation coefficients between the investigated parameters

	Antioxidant activity	Vitamin C	Total phenol	SSC
Vitamin C	0.38*			
Total phenol	0.92***	0.40*		
SSC	0.39*	0.01ns	0.40*	
pH	-0.37*	-0.09ns	-0.37*	-0.65**

SSC: Soluble solid content, ns: Non-significant *, **, ***: are mean statistical significance at P <0.05, P <0.01 and P <0.001, respectively.

Relations between investigated properties are given in Table 3. Based on the results, a significant negative correlation (r= -0.37*) was determined between total phenol and pH features. This situation is thought to be due to the acidic character of phenolic acids, and their solubility increases with the increase of acidity. A similar situation was determined between the ascorbic acid, which is an active ingredient of vitamin C and an organic acid, and the pH properties, but no statistical significance was found. This common situation also enabled the determination of an important and positive correlation between total phenol and vitamin C (r =0.40*). These two properties both with high antioxidant effect were found to be in a positive relationship with antioxidant activity as expected but contribution of total phenol (r = 0.92***) to antioxidant activity was found higher than vitamin C (r = 0.38*). Giampieri et al. (2015) and Schempp et al. (2016) stated that organic and phenolic acids show high antioxidant activity, and there are many studies reporting a high positive relationship between them (Akkurt et al., 2020; Polat et al., 2020a). In addition, amounts of these compounds increase in an acidic environment (Vieira et al., 2009; Mertoğlu and Evrenosoğlu, 2019).

Conclusion

As a result of the study, it was found that there is a high variation among cherry cultivars in terms of phytochemical properties. It is concluded that investigated cultivars can be evaluated in different breeding programs and consumption patterns.

In industrial crop processing stages, the high soluble soldi content increases the yield. On the other hand, low pH is important in terms of restricting microorganism activity and continuity of stability. In this context, it can be said that the cultivars Regina, 0900 Ziraat and Kordia seem promising. Sweetheart, Kordia and Regina have high antioxidant activities and come to the forefront in terms of human health.

According to result, low pH should be among the parameters to be considered as an important early selection criteria for the improvement of fruit biochemistry.

Investigated properties are quantitative and due to their high dependence on environmental conditions, such studies should be periodically repeated in different locations. In addition, due to the low heritability of quantitative properties, the basis should be prepared for the correct planning in breeding studies by revealing the heritage patterns.

Conflict of Interest: The authors declare no conflict of interest.

Contribution Rate Statement Summary: The authors declare that they have contributed equally to the article

References

Acero, N., Gradillas, A., Beltran, M., Garcia, A. Ve Mingarro, D.M. 2019. Comparison of Phenolic Compounds Profile and Antioxidant Properties of Different Sweet Cherry (*Prunus avium* L.) Varieties. Food chemistry, 2019, 279: 260-271.

Akkurt, E., Mertoğlu, K., & Evrenosoğlu, Y. 2020. Vista Bella Elma Çeşidinde Farklı Tozlayıcı Çeşitlerin Meyve Tutumu ve Bazı Meyve Kalite Özellikleri Üzerine Etkisi. *ANADOLU Ege Tarımsal Araştırma Enstitüsü Dergisi*, *30*(2), 284-294.

Cevallos-Casals, B.A., Byrne, D., Okie, W.R. ve Cisneros-Zevallos, L. 2006. Selecting New Peach and Plum Genotypes Rich in Phenolic Compounds and Enhanced Functional Properties. Food chemistry, 2006, 96(2): 273-280.

Çavuşoğlu, Ş., Tekin, O., Bahar, A., Ercişli, S., Özrenk, K., & Durmaz, N. 2018. Effects of Post-Harvest UV-C and Hot Water Treatments on Quality Attributes of '0900 Ziraat'Cherries throughout the Cold Storage in Modified Atmosphere Packages. *Türk Tarım ve Doğa Bilimleri Dergisi*, *5*(4), 634-642.

Demir, G. ve Aktaş, N. 2018. A Research on Functional Food Knowledge, Preference and

Consumption of University Students. Üniversite Öğrencilerinin Fonksiyonel Besin Bilgi, Tercih ve Tüketimleri Üzerine Bir Araştırma. Journal of Human Sciences, 2018, 15(4): 2387-2397.

Eroğul, D. (2016). İzmir İlinde yetiştirilen bazı önemli kiraz çeşitlerinin fiziksel ve kimyasal özelliklerinin belirlenmesi. *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi*, *26*(4), 579-585.

Eskimez, İ., Polat, M., & Mertoğlu, K. (2020). M9 Anacı Üzerine Aşılı Arapkızı, Jonagold ve Fuji Kiku Elma (Malus domestica Borkh.) Çeşitlerinin Isparta Ekolojik Koşullarında Fenolojik ve Fiziko-Kimyasal Özellikleri. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi*, *6*(2), 152-159.

Florkowski, W. J., & Lysiak, G. (2015). Quality attribute-price relationship: modernization of the sweet cherry sector in Poland. *Problems of World Agriculture/Problemy Rolnictwa Światowego*, *15*(1827-2016-147713), 41-55.

Giampieri, F., Forbes-Hernveez, T.Y., Gasparrini, M., Alvarez-Suarez, J.M., Afrin, S., Bompadre, S., ... ve Battino, M. 2015. Strawberry as a Health Promoter: An Evidence Based Review. Food & Function, 2015, 6(5): 1386-1398.

Gonçalves, A. C., Campos, G., Alves, G., Garcia-Viguera, C., Moreno, D. A., & Silva, L. R. (2020). Physical and phytochemical composition of 23 Portuguese sweet cherries as conditioned by variety (or genotype). *Food Chemistry*, *335*, 127637.

Göksel, Z., & Aksoy, U. (2014). Sofralık bazı kiraz çeşitlerinin fizikokimyasal özellikleri. *Türk Tarım ve Doğa Bilimleri Dergisi*, *1*(Özel Sayı-2), 1856-1862.

Gundogdu, M., & Bilge, U. (2012). Determination of organics, phenolics, sugars and vitamin C contents of some cherry cultivars (Prunus avium). *International Journal of Agriculture and Biology*, *14*(4).

Gundogdu, M., Canan, I. ve Okatan, V. 2018. Bioactive Contents and Some Horticultural Characteristics of Local Apple Genotypes from Turkey. JAPS: Journal of Animal & Plant Sciences, 2018, 28(3): 865-874.

Hayaloglu, A. A., & Demir, N. (2015). Physicochemical characteristics, antioxidant activity, organic acid and sugar contents of 12 sweet cherry (Prunus avium L.) cultivars grown in Turkey. *Journal of Food Science*, *80*(3), C564-C570.

Karaat, F. E., Gündüz, K., Saraçoğlu, O., & Yıldırım, H. (2019). Pomological and phytochemical evaluation of different cherry species: mahaleb (Prunus mahaleb L.), wild sweet cherry (Prunus avium L.) and wild sour cherry (Prunus cerasus L.), sweet and sour cherry cultivars. *Acta Scientiarum Polonorum. Hortorum Cultus*, *18*(4).

Karaçalı, I. (2012). Bahçe Ürünlerinin Muhafazası ve Pazarlanması. Hasat Öncesi Dönemde Gelişmeyi Etkileyen Faktörler. Ege Üniv. Yay. No: 494. Bornova, İzmir.

Mertoglu, K., Eskimez, I., Polat, M., Okatan, V, Korkmaz, N., Gulbandılar, A., Bulduk, I. (2021). Determination of Anti-Microbial and Phyto-Chemical Characteristics of Some Blackberry Cultivars. Fresenius Enviromental Bulletin, 30(02A), 1789-1795.

Mertoğlu, K., Gülbandılar, A., & Bulduk, İ. (2020). Growing conditions effect on fruit phytochemical composition and anti-microbial activity of plum (cv. Black Diamond). *International Journal of Agriculture Forestry and Life Sciences*, *4*(1), 56-61.

Mertoğlu, K., ve Evrenosoğlu, Y. (2019). Bazı Elma ve Armut Çeşitlerinde Fitokimyasal Özelliklerin Belirlenmesi. *Ziraat Fakültesi Dergisi*, *14*(1), 11-20.

Meteoroloji 3. Bölge Müdürlüğü – Eskişehir., 2015. Eskişehir merkez meteorolojik verileri (Erişim tarihi: Nisan, 2020).

Okatan, V. 2020. Antioxidant properties and phenolic profile of the most widely appreciated cultivated berry species: A comparative study. *Folia Hort.,* 32(1): 79-85.

Ouaabou, R., Ennahli, S., Nabil, B., Hssaini, L., Hanine, H., Hernández, F., ... & Mahrouz, M. (2020). Multivariate Cherry Quality Assessment Using Morphological, Biochemical and Volatile Compound Traits. *International Journal of Fruit Science*, 1-20.

Polat, M., K. Mertoglu, I. Eskimez and V. Okatan. 2020a. Effects of the fruiting period and growing seasons on market quality in goji berry (*Lycium barbarum* L.). *Folia Hort.*, 32(2): 1-11.

Polat, M., Mertoğlu, K., & Eskimez, İ. 2020b. Elmada Bazı Özelliklerin Birlikte Ele Alınabilme Potansiyelleri: Pinova Örneği. *Ziraat Mühendisliği*, (370), 115-125.

Polat, M., Okatan, V., Güçlü, S.F. ve Çolak, A.M. 2018. Determination of Some Chemical Characteristics and Total Antioxidant Capacity in Apple Varieties Grown in Posof/Ardahan Region. International Journal of Agriculture, Environment and Food Sciences, 2018, 2(4): 131-134.

Prvulovic, D., Popović, M., Malenčić, Đ., Ljubojević, M., & Ognjanov, V. (2011). Phenolic compounds in sweet cherry (Prunus Avium L.) petioles and their antioxidant properties. *Research Journal of Agricultural Science*, *43*(2), 198-202.

Ramirez-Ambrosi, M., Lopez-Marquez, D.M., Abad-García, B., Dapena, E., Berrueta, L.A., ve Gallo, B. 2015. Comparative Study of Phenolic Profile of Fruit and Juice Samples of A Progeny of 'Meana'×'Florina' from An Asturian Cider Apple Breeding Program. European Food Research and Technology, 2015, 241(6): 769-784.

Romano, G. S., Cittadini, E. D., Pugh, B., & Schouten, R. (2006). Sweet cherry quality in the horticultural production chain. *Stewart Postharvest Review*, *6*(2), 1-8.

Sahoo, T., Verma, M.K., Singh, S.K., Thakre, M., Sharma, R.R. ve Jaiswal, S. 2017. Heterosis and Heterobeltiosis for Morpho-Physical, Phenolics, Flavonoids and Antioxidants in Grape (*Vitis vinifera*) Hybrids. Indian Journal of Agricultural Sciences, 2017, 87(6): 759-764.

Saracoglu, O., Ozturk, B., Yildiz, K., & Kucuker, E. (2017). Pre-harvest methyl jasmonate treatments delayed ripening and improved quality of sweet cherry fruits. *Scientia Horticulturae*, *226*, 19-23.

Schempp, H., Christof, S., Mayr, U. ve Treutter, D. 2016. Phenolic Compounds in Juices of Apple Cultivars and Their Relation to Antioxidant Activity. Journal of Applied Botany and Food Quality, 2016, 89: 11-20.

Selcuk, N ve Erkan, M. 2016. Impact of Passive Modified Atmosphere Packaging on Physicochemical Properties, Bioactive Compounds, and Quality Attributes of Sweet Pomegranates, Turkish Journal of Agriculture and Forestry, 2016, 40(4): 475-488.

Sirbu, S., Oprica, L., Poroch, V., Iurea, E., Corneanu, M., & Grigore, M. N. (2018). Physical Parameters, Total Phenolics, Flavonoids and Vitamin C Content of Nine Sweet Cherry Cultivars. *REVISTA DE CHIMIE*, *69*(1), 125-129.

Skrzynski, J., Leja, M., Gonkiewicz, A., & Banach, P. (2016). Cultivar effect on the sweet cherry antioxidant and some chemical attributes. *Folia Horticulturae*, *28*(1), 95-102.

Tang, Y. ve Tsao, R. 2017. Phytochemicals in Quinoa and Amaranth Grains and Their Antioxidant, Anti-İnflammatory, and Potential Health Beneficial Effects: A Review. Molecular Nutrition & Food Research, 61(7): 1600767.

Tiwari, U. and Cummins, E. (2013) Factors Influencing Levels of Phytochemicals in Selected Fruit and Vegetables During Pre- and Post-Harvest Food Processing Operations. Food Research International. 50(2), 497-506.

Vieira, F.G.K., Borges, G.D.S.C., Copetti, C., Amboni, R.D.D.M.C., Denardi, F. ve Fett, R. 2009. Physico-Chemical and Antioxidant Properties of Six Apple Cultivars (*Malus domestica* Borkh) Grown in Southern Brazil. Scientia Horticulturae, 2009, 122(3): 421-425.

Yazici, K. ve Şahin, A. 2016. Characterization of Pomegranate (*Punica granatum* L.) Hybrids and Their Potential Use in Further Breeding. Turkish Journal of Agriculture ve Forestry, 2016, 40(6): 813-824.

Zar, JH. 2013. Biostatistical Analysis: Pearson New International Edition. Pearson Higher Ed.