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ORIGINAL ARTICLE

Evaluation of the Effect of Different Harvest Time on the Fruit Quality of Foşa Nut

Ozgun Kalkisim · Ali Turan · Zuhal Okcu · Duygu Ozdes

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Abstract This study was carried out in Arsin (Trabzon/Turkey) in 2011. The effects of different harvest time and altitudes on the quality of the nuts have been investigated. The study was performed on Foşa hazelnut and the harvest process has been conducted at three terms, which are on normal harvest time and ten days before and after harvest time. The harvested nuts were dried in the shade on the concrete floor until their moisture content decreased to 5%. Some properties of nuts including yield, fruit weight, internal weight, shell thickness, and protein, oleic, and linoleic acid amounts have been investigated. As evaluated all of the fruit properties it can be concluded that 11 August is the most suitable harvest date for coast zone. On the other hand, no significant differences were obtained in the point of protein, oleic, and linoleic acid amounts for different harvest time and altitudes.

O. Kalkisim (✉)
Department of Plant and Animal Production, Gumushane Vocational School, Gumushane University,
29100 Gumushane, Türkei
e-mail: okalkisim5@hotmail.com

A. Turan
Technical Sciences Vocational School, Nuts Expertise Program, Giresun University,
Giresun, Türkei

Z. Okcu
Faculty of Engineering and Natural Sciences, Food Engineering Department, Gumushane University,
29100 Gumushane, Türkei

D. Ozdes
Department of Chemical and Chemical Process Technology, Gumushane Vocational School, Gumushane University,
29100 Gumushane, Türkei

Keywords Harvest time · Hazelnut · Nut quality

Einfluss unterschiedlicher Erntezeiten auf die Qualität von Foşa Haselnüssen

Zusammenfassung Diese Studie wurde in Arsin (Trabzon/Türkei) im Jahre 2011 durchgeführt. Dabei wurden die Auswirkungen unterschiedlicher Erntezeiten auf die Qualität von Haselnüssen und deren Ertragshöhe untersucht. Auftraggeber dieser Studie war Foşa-Haselnuss. Die Ernte wurde zu drei unterschiedlichen Zeitpunkten vorgenommen: zur üblichen Erntezeit, 10 Tage vor und 10 Tage nach der üblichen Erntezeit. Die geernteten Nüsse wurden im Schatten getrocknet bis sich ihr Feuchtigkeitsgehalt um 5% verringert hatte. Dabei wurden einige Eigenschaften der Haselnüsse, wie der Ertrag, das Fruchtgewicht, das Fruchtkerngewicht, die Schalendicke, die Proteine, die Ölsäure und die Linolsäure untersucht. Unter Berücksichtigung aller Fruchteigenschaften ließ sich der Schluss ziehen, dass der 11. August 2011 der optimalste Erntezeitpunkt für die Küstenregion am Schwarzen Meer darstellte. Weiter konnten keine signifikanten Unterschiede zu den verschiedenen Erntezeitpunkten hinsichtlich der Gehalte an Proteinen, Linolsäure und Ölsäure festgestellt werden.

Schlüsselwörter Erntetermin · Haselnuss · Nuss-Qualität

Introduction

The producers usually harvest the nuts earlier in Turkey because of the difficulties in finding workers, land construction, being officer or expatriate of the important part of the

farmers, and the climate conditions at the harvest terms (Beyhan 2000). Besides these reasons, the mixture of types also leads to earlier harvest. There is almost no unmixed garden in our country except Tombul nut plantations in Giresun. Therefore the producers prefer to collect the nuts all at once in order to reduce the harvest costs. In this case, the harvest time is suitable for some varieties but it may be early for other varieties.

It is important to make the nut harvest on time to obtain high fruit quality and yield (Beyhan 2000). It is known that early nut harvest induces significant quality and weight losses (Okay et al. 1986; Ayfer et al. 1986; Köksal 2002). The crinky internal rate, composition of fatty acids, bleaching rate, fat rate, and especially yield can be considered among the quality losses. Besides these quality losses, the high water content at the early harvest time causes an increase in the sensitivity of the product against the microbial activities and a decrease in the self-life of the product (Özdemir et al. 1998; Özay et al. 2005).

The optimum harvest time of nuts varies by years depending on ecological conditions. Accordingly, the harvest should be made by phenological observation. The quite flushing of husks, easily rotation of fruit in husk, taking its own color of hard shell, and the dropping of nuts (about $^{3}/_{4}$ rate) when shaken indicate the optimum harvest time for nuts (Beyhan 2000; Okay et al. 1986; Çakırmelikoğlu and Çalışkan 1993). Therefore, the harvest process from bough is evaluated as early harvest and disapproved except obligatory cases. This may be approved in the roadside and streambeds side, in where the fruit can loss, and in the garden in where the garden bottom cleaning is not made.

This study was performed to indicate the effect of different harvest times on some fruit properties in Arsin (Trabzon/Turkey) and to determine the most suitable harvest time for Foşa nut type. In the presented investigation, it is also aimed to demonstrate the possible quality loss of the nuts, which were taken at different altitudes at the same harvest term.

Materials and Methods

Materials

This study was carried out in Arsin, a county of Trabzon (Turkey), in 2011. Foşa nuts were used as material. The harvest process was performed at three terms, which are on normal harvest time and ten days before and after harvest time and at three areas (coast, middle and high zone) in the county. The harvest was made in 01 August (early harvest), 11 August (common and suitable harvest time) and 21 August (late harvest). The harvested nuts were separated from their clusters at the same day in the laboratory and dried in the shade on the concrete floor until their moisture content decreased to 5 %. The tests were performed in five replicates according to the coincidence blocks experimental design. In each replicate three seedbeds were used and 250 clusters were collected around each seedbed.

Methods

In the presented investigation, the yield (%), fruit weight (g), internal weight (g), shell thickness (mm), fruit width (mm), fruit height (mm) and fruit thickness (mm) were established. In calculation of yield, the creased endocarps were incorporated in to robust endocarps. The fruit and internal weight were determined by the ratio of total weight and the number of fruit. For this purpose, a digital scale with a sensitivity of 0.01 mg was used. The fruit sizes were measured with digital calipers with a sensitivity of 0.001 mm.

The fatty acids (oleic and linoleic acid) and protein contents of nuts were determined by a HPLC (Shimadzu Prominence). Before the analysis, 100 mg of the nut samples were weighed in a 20 mL test tube. The samples were dissolved with 10 mL of hexane. Then 100 μL of 2.0 M KOH prepared in methanol was added to the mixture. The tube was closed and shaked with vortex for 30 s. Then it was centrifuged and the clear supernatant was transferred to a 2.0 mL auto sampler vial (AOAC). The statistical analyses were carried out by using SPSS 13® software package program with Duncan's multiple comparison method.

Results and Discussion

The fruit properties of Foşa nuts according to different harvest time were determined (Table 1). The fruit weight for the late harvest time was found to be statistically different from other harvest times. The highest fruit weight was obtained at the late harvest time. This result was supported by Beyhan's (Beyhan 2000) and Savran's (Savran 2010) investigations in which they indicated that "the fruits which were harvested on time fill their inside exactly". Therefore, being heavier of the late harvested fruits is an expected result. The shell thickness was found to be statistically insignificant for different harvest terms. However, the shell thickness was the highest for the late harvest terms. It is known that the shell thickness does not change for late harvest term. This may be the result of the measurement from different points besides the clonal difference. In addition, the unbalanced fertilization may be the reason of this result since the excessive nitrogen fertilization increases the shell thickness (Genç 1976; Ağaoğlu et al. 2001). At the late harvest time, in which the fruit weight is the highest, the shell thickness is also found to be the highest (Table 1).

The highest yield was obtained for the harvest which was made on time and was found to be statistically dif-

Table 1 The changes in fruit properties and yield of Foşa nut according to different harvest times

	FH (mm)	FW (mm)	FS (mm)	FWE (g)	ST (mm)
Early harvest	18.00 ± 1.15a	17.29 ± 1.40a	15.85 ± 1.11a	18.04 ± 2.55b	1.14 ± 0.17a
Harvest on time	17.94 ± 0.97a	17.20 ± 1.19a	15.84 ± 0.72a	18.81 ± 1.96b	1.13 ± 0.22a
Late harvest	17.98 ± 1.29a	17.56 ± 1.11a	15.93 ± 1.00a	20.19 ± 1.88a	1.19 ± 0.24a
	IH (mm)	**IW (mm)**	**IT (mm)**	**IWE (g)**	**Yield (%)**
Early harvest	12.75 ± 1.29b	12.93 ± 1.26a	11.95 ± 1.30a	8.63 ± 1.50b	47.22 ± 3.41c
Harvest on time	13.60 ± 1.03a	13.27 ± 1.25a	12.50 ± 1.07a	9.89 ± 1.09a	52.22 ± 2.72a
Late harvest	13.53 ± 1.04a	13.60 ± 1.57a	12.67 ± 1.53a	10.22 ± 1.22a	50.30 ± 4.87b

FH fruit height, *FW* fruit width, *FS* fruit shell, *FWE* fruit weight, *ST* shell thickness, *IH* inner height, *IW* inner width, *IT* inner thickness, *IWE* inner weight.

The effect of the harvest time on the fruit quality is important at $P < 0.05$ level

Table 2 The changes in fruit properties and yield of Foşa nut according to different altitude zones

	FH (mm)	FW (mm)	FS (mm)	FWE (g)	ST (mm)
Coast zone	18.28 ± 1.29a	16.93 ± 1.17 b	15.57 ± 0.97 a	19.96 ± 2.21 a	1.16 ± 0.12 a
Middle zone	17.84 ± 1.13a	18.12 ± 1.07 a	16.10 ± 0.95 a	20.19 ± 1.27 a	1.26 ± 0.23 a
High zone	17.80 ± 0.92a	17.00 ± 1.10 b	15.95 ± 0.86 a	16.89 ± 1.67 b	1.04 ± 0.21 b
	IH (mm)	**IW (mm)**	**IT (mm)**	**IWE (g)**	**Yield (%)**
Coast zone	13.84 ± 1.14 a	13.03 ± 1.64 b	12.20 ± 1.64 a	10.11 ± 1.40 a	50.26 ± 4.09 a
Middle zone	13.39 ± 0.98 a	13.95 ± 1.01 a	12.63 ± 0.77 a	9.96 ± 0.98 a	48.89 ± 4.03 a
High zone	12.66 ± 1.13 b	12.82 ± 1.18 b	12.29 ± 1.43 a	8.67 ± 1.47 b	50.59 ± 4.62 a

ferent from other terms. The lowest yield was obtained at the earlier harvest time. This result was supported by the literature (Çakırmelikoğlu and Çalışkan 1993). The crinky internal rate is considered as one of the drawbacks of the early harvest (Beyhan 2000; Savran 2010; Turan 2007). The undevelopment of inner fruit leads to decrease in the yield. The highest value of the internal weight was obtained at the late harvest time and this value was statistically in the same group with the on time harvest. The decrease in the yield at the last harvest time results from the shell thickness.

The effects of altitudes on the quality of fruit were determined (Table 2). The highest fruit weight was obtained at the middle zone and this value was statistically in the same group with the coast zone. The difference is considered normal since the growing occurs earlier in coast and middle zone. The thinnest shell was obtained in the high zone. Because of the ecological conditions at the high zone, the fruit is smaller than the fruit from the coast and middle zone. As the fruit becomes smaller, the shell becomes slimmer and as the fruit becomes larger, the shell thickness increases (Turan 2007). Therefore, the highest shell thickness at high zone is evaluated because of ecological conditions. In each 100 m increase in altitude, the temperature decreases 0.6–1.0 °C (Ağaoğlu et al. 2001), so it is expected that the vegetation should be back by the low altitude. Besides the increase in the height, the hardening of the weather also affects the fruit growth (Karaçalı 2002).

The fat and protein changes of fruit of Foşa nut by the different altitudes and terms were obtained (Table 3). As evaluated the data in terms of height, it was observed that

Table 3 The changes in fat and protein amounts of Foşa nut according to different altitude zones and terms

		Oleic acid (%)	Linoleic acid (%)	Protein (%)
Altitudes	High zone	84.88 a	8.71 a	14.06 b
	Coast zone	82.76 b	8.71 a	15.03 a
	Middle zone	81.90 b	10.62 a	13.98 b
Terms	I.Term	82.24 a	10.22 a	14.85 a
	II.Term	83.33 a	9.12 a	14.46 a
	III.Term	83.97 a	8.69 a	13.76 b

The effects of the altitude and term differences on the fat and protein amount is important at $P < 0.05$ level

the oleic acid amount was the highest (84.88 %) at high zone and the lowest (81.90 %) at middle zone. These values were similar to previous studies (Tous et al. 2001; Guneş et al. 2010; Karaosmanoğlu 2012; Moser 2012). However, in the high zone the oleic acid amount was higher than obtained in the previous investigations. This may be the results of the differences in cultural applications, species, clonal and harvest terms. As evaluated the data cyclically, although the oleic acid amount was the highest (83.97 %) in the third term, there was no statistically significant difference between the harvest terms.

The highest linoleic acid amount (10.62 %) was obtained in the middle zone. The linoleic acid amounts are the same in the coast and high zones. These values are higher than some of the previous studies (Guneş et al. 2010), and lower than some of the studies in literature (Köksal et al. 2006). This difference may arise from the differences in ecology, ground, vector, cultural applications, and species. The sta-

tistical differences were insignificant between the zones. This result showed that the height difference is ineffective on the linoleic acid changes. Among the different harvest terms, although the highest linoleic acid amount (10.22%) was obtained in the first term, there were no statistically differences between the other terms. As evaluated these data, it can be concluded that the harvest time is ineffective on the oleic and linoleic acid amounts.

The highest protein amount (15.04%) was obtained in the coast zone. There were no statistically differences between the other zones. The obtained values were similar to previous studies (Guneş et al. 2010; Köksal et al. 2006). However, the protein amount was found to be high (20.8%) in some of the studies for different species (Köksal et al. 2006). As evaluated the data cyclically, the highest protein amount (14.85%) was obtained in the first term. The first and second terms were statistically in the same group. The lowest value (13.76%) was obtained for the third term, which is at the different group.

The results of this investigation, which are similar to other reported studies in the literature, indicate that significant weight and yield losses occur at earlier harvest. In the present study, it is revealed that making the harvest on time, the postharvest losses decrease and the farmers generate more revenue as indicated in the previous researches. On the other hand, in the land works, it is noticed that the harvest is made at different heights at same date. It is known that the suitable harvest time for coast is not suitable for middle and high zone. In the study, it was observed that the harvest, which is made at the same time, results significant quality losses with respect to physical properties without distinction of zones. However, no significant differences were obtained in terms of oleic acid, linoleic acid and protein amounts for both different harvest terms and zones. A difference should have been expected because the altitudes and times were different. This may be due to the clonal differences between the species. As a result, for Arsin county at coast zone the suitable harvest time was determined 11 August by taking into account of height differences. However, it should be noted that this date might vary from year to year according to phenology.

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