arastirma.tarimorman.gov.tr/bursagida
Gıda ve Yem Bilimi - Teknolojisi Dergisi / Journal of Food and Feed Science - Technology 25: 39-47 (2021/1) ISSN 1303-3107

Özgün Araştırma/Original Article

Semi-Mechanical Harvesting Method Effect on Oil Content and Fat Composition of Sesame

Yarı Mekanik Hasat Yönteminin Susam Yağ İçeriği ve Yağ Bileşimi Üzerindeki Etkisi

Yasemin VURARAK[1]

(1)*Dr, Eastern Mediterranean Agricultural Research Institute*, P.O.Box 45, ADANA, TURKEY ***ORCID ID 0000-0003-1048-788X***

**: Yazışmalardan sorumlu yazar /Corresponding author, yasemin.vurarak@tarimorman.gov.tr*

Geliş Tarihi:11.11.2020
Kabul Tarihi:22.01.2021

Abstract

Objective: Sesame (*Sesamum indicum* L.) seed is a high-quality oil plant with high oleic, linoleic fatty acid composition and sesamol content. However, due to the morphological and physiological characteristics combine harvesting are almost impossible in Turkey. The objective of our experiment was to determine the oil content and fatty acid composition of sesame semi-mechanized harvesting in main and second crop growing conditions.

Materials and Methods: This study was conducted at the experimental area of Eastern Mediterranean Agricultural Research Institute, Adana in Turkey. Semi-mechanized harvest and traditional harvest were a randomized block design with 4 replications for 2 years as a main and second crop growing conditions.

Results and Conclusion: At the end of the study, it was determined that the semi-mechanized harvest had not negative effect on oil and fatty acid composition. It was observed that reaper-binder (semi-mechanized method) could be practicable for sesame harvesting in Turkey.

Keywords: Sesame, Harvest, Reaper-Binder, Quality, Fatty Acids

Öz

Amaç: Susam (*Sesamum indicum* L.*),* yüksek oleik, linoleik yağ asidi bileşimi ve sesamol içeriğine sahip yüksek kaliteli bir yağ bitkisidir. Ancak, morfolojik ve fizyolojik özelliklerinden dolayı Türkiye'de biçerdöver ile hasat etmek neredeyse imkansızdır. Bu çalışmada, yarı mekanize ve geleneksel hasat yöntemlerinin ana ve ikinci ürün koşullarında yağ ve yağ asitleri açısından etkisinin belirlenmesi amaçlanmıştır.

Materyal ve Yöntem: Denemeler, Türkiye'de Doğu akdeniz Tarımsal Araştırma Enstitüsü'nün deneme alanlarında yürütülmüştür. Çalışmada, 2 yıl süresince 4 tekrarlı olarak tesadüf blokları deneme desenine göre yarı mekanize ve geleneksel hasat yöntemleri ana ve ikinci ürün koşullarında karşılaştırılmıştır.

Bulgular ve Sonuç: Çalışmanın sonunda yarı mekanize hasadın yağ ve yağ asidi kompozisyonu üzerinde olumsuz bir etkisi olmadığı belirlenmiştir. Biçerbağların (yarı mekanize yöntem) susam hasadında kullanılabileceği belirlenmiştir.

Anahtar sözcükler: Susam, hasat, kalite, biçerbağlar, yağ asitleri

1. Introduction

Sesame (*Sesamum indicum* L.*)* is a tropical or subtropical climate plant from the family Pedaliaceae and it is well adapted to the tropical and subtropical climates, mostly north of the equatorial belt (Ashri 2007). Nowadays, sesame has been nowadays grown in more than 60 countries around the world (Kurt 2018). In its content, oleic and linoleic acids are the predominant fatty acids and constitute more than 80% of the total fatty acid content (Mondal et al. 2010). The fatty acid composition in sesame seeds consists of oleic (35,9–42,3%) and linoleic (41,5–47,9%) acids from 80% of total

fatty acids; less than 20% are saturated fatty acids, mainly palmitic (7,9–12%) and stearic acids (4,8–6,1%) (Hwang 2005; Gharby et al. 2018). Sesame oil has widely application area for human nutrition and industry. Morover, sesame oil which remains intact for a long time thanks to the sesamol ingredient in its composition is counted among precious oils with an average content of 44% oil, 25% protein content (Langham 1985). The growing period of sesame is between 90-120 days depends on the variation. The fertilizer requirements of sesame are low. It is tolerant of heat and drought (Langham and Wiemers 2002).

Lack of closed capsules cultivars, capsule shattering, uneven ripening, profuse branching and indeterminate growth habit, are the limiting factors in sesame production worldwide (Tripathy et al. 2019). In additional, this characters of sesame are not suitable for mechanized harvesting (Langham and Wiemers 2002) and limited for commercial production in countries that have no available labor. Despite the importance of sesame seeds, the production of sesame in Turkey had been on a negligible scale although it is gradually increasing. Because sesame production cannot meet demand for sesame seed. Sesame cannot be harvested with combine harvesters in Turkey because sesame with closed capsules are not available. Furthermore, not every plant can reach the harvest stage in the same period. maturity occurs upwards from the lower capsules in sesame plant. (Uğurluay 2002, Nobre et al. 2013). This case leads to an increase in production costs. At expansion of sesame plant in the world finds several obstacles, such as the lack of technologies to mechanized, mainly in the harvesting process (Queiroga et al. 2009). Manual harvesting is effected the time of exposure to the climatic conditions. Hence, seed losses are increasing (Georgiev et al. 2008). The maturation of the sesame capsules is uneven throughout the canopy of the plant. Hence, promotes the opening of the capsules from the base to the apex, making the harvest a determining factor in the quality of the seeds (Nobre et al. 2013). The harvest in Turkey is traditional method which using labor leaves start to yellow and the tips the capsules start to crack. The plant is pulled from the root then bundled and stacked and dried in the open air. In case of late harvesting, the lower capsules shattering and top quality kernels spill out. In early harvests, maturation is not complete and the grain remains empty and yield losses increase. Countries that have well-suited climates, such as the United States, have varieties which do not shattering the capsule (Uğruluay 2002). These varieties are harvested by combine harvesters using some harvest aids.

The fatty acid composition effects the physical and chemical properties of essential oil which have an important place in human and animal diets. It is desirable that this composition is not affected by agricultural activities. One of these activities is the harvesting method. Fat and fatty acids are found in a different composition in each oil plant (Baydar 2000). Fatty acids in oil plants are variable according to the conditions. Determination of the change in quality in different conditions is important in determining area where the oil is to be used (Karaca and Aytac 2007). The composition of oil and fatty acid is affected by environmental and climatic factors and there are studies which indicate that these properties are also affected by practices and conditions such as planting and harvesting time (Uğurluay 2002), drought (Dwivedi et al. 1996, Flagella et al. 2002), fertilization (Ahmad and Abdin 2000; Dubey et al. 2001). Determining the effects of traditional harvesting and alternative mechanized harvesting methods on the composition of sesame oil and fatty acid has importance in terms of the extension of sesame growing in Turkey. When the correct determination of harvest method and date, sesame seed loss is decreased. There is a limited period of 5-8 days between the start and completion date of harvesting for an acceptable capsule shattering and yield loss. For each subsequent day, the amount of seed loss increases rapidly with the amount of capsule shattering. Starting from the date of harvesting, the grain loss from shattering capsules on the first day of failure to harvest is up to 5%, 10% on the second day, 25% on the fourth day and 60% on the sixth day (Uğurluay 2002). Harvesting practices vary from country to country and from one place to another within countries. Its capsule shattering nature is the most problematic issue because of high seed losses (up to 50%) at harvesting time (Weiss 1971). The manually harvest is the most difficult for sesame plant. In addition, this method is laborious and time consuming operation which accounts for more than 70% of the total cost of crop production (Adil and

Ahmed 2015). In traditional harvests, the ability to carry out the harvesting at the appropriate time and speed depends on the number of laborers. Difficulty in engaging workers has led to the search for alternative methods to traditional sesame harvesting. There are a limited number of studies regarding sesame harvest mechanization in Turkey. However, mechanized systems are not used widely to harvest sesame yet. The main reason is that the negative opinion of sesame producers regarding the poorer quality (Oil and fatty acid, etc.) of sesame plants without roots harvested with semi-mechanized harvesting systems compared to those harvested manually. There are no scientific studies to refute this negative opinion.

The objective of this study was to determinate the effect of different harvesting methods on some quality characteristics of sesame grown as a main and second crop in Mediterranean region (Turkey). In this research; oil and oil fatty acid content characteristics and fatty acids composition of subjects were investigated.

2. Materials and Methods

The experiments were conducted in the experimental fields of the Eastern Mediterranean Agricultural Research Institute, Adana, Turkey (lat. 36°51´N, long. 35°, 20´E, and 12 m elevation; mildly alkaline soil type), as a main and second crop growing conditions. The soil texture was clay loam. The soil tests indicated that pH about of 7.5. In addition, the organic matter and nitrogen content of the soil were very low.

Orhangazi-99 variety sesame seeds were used as plant material in the study. It matures in 92-100 days. Its oil ratio is 55,3-57,5% and yield varies between 141-268 kg da^{-1}. This sesame variety was preferred due to poor branching. This feature was determined suitable for semi-mechanized harvest (Vurarak et al. 2014).

The technical characteristics of the reaper-binder, in which the harvesting and binding were re-arranged according to the sesame plant are given in Table 1.

Table 1. The reaper-binder harvesting machine and some technical specifiations

Width of ımplement (cm)	140
Capacity (da h^{-1})	8
Cutting height (cm)	Adjustable
Binding height (cm)	28
General length (cm)	316
General width (cm)	196
General height (cm)	110
Weight (kg)	340

This study was conducted in Adana province in Turkey and in this region, winters are mild and rainy, whereas summers are dry and warm, which is a typical of a Mediterranean climate. The climate data during the first and second years growing period was shown in Table 2.

Table 2. Temperature (°C), relative humanity (%), total rainfall (mm), and wind speed (m s^{-1}) for years in the experimental area

Months	Mean of temperature (°C)		Mean of relative humidity (%)		Total rainfall (mm)		Mean of Wind speed (m s^{-1})	
	First year	Second year	First year	Second year	First year	Second year	First year	Second year
April	16,5	18,1	65,4	68,3	117,3	36,0	0	9,7
May	20,1	20,8	70,2	74,0	30,0	97,0	0	9,7
June	24,5	26,7	72,4	66,2	0	35,5	9,4	7,5
July	27,9	29,3	71,5	65,3	0	18,3	8,8	10,6
August	28,8	29,3	68,6	62,5	0	0	9,7	10,2
September	26,9	27,0	65,7	64,9	0	0	9,6	10,0
October	20,7	22,6	49,7	61,9	6	51,9	11,7	35,0

Source: Dataem, 2017; http://arastirma.tarim.gov.tr/cukurovataem/Link/3/Iklim-Verileri

The experiment plots were consisted of 8 rows 30,0 m long and 70 cm apart. In additional, 4 central rows were harvested. The trial subjects are coded as follows;

H_1:'semi-mechanized harvest' during pre-maturity term
H_2:'manual harvest' (traditional/manually) during pre-maturity term
H_3:'semi-mechanized harvest' during full maturity term
H_4:'manual harvest' (traditional/manually) during full maturity term

During the pre-maturity harvests (H_1 and H_2) which were carried out manually and with the semi-mechanized system, the period when the lower leaves had started to yellow and fall and the color of the seeds of the lower capsules had a white-yellow color was taken into consideration. At this period, shattering level of the capsule ends is less than 10%. In harvests (H_3 and H_4) made with the manual and semi-mechanized system during the full maturity period, a 56-60% moisture content corresponding to at least 10% of the capsules shattering was taken into consideration (Uğurluay 2002).

Agricultural Activities: The seeds were sown in line by pneumatic sowing machine with 70x15 cm distance on last week of April for main crop, on last week June for second crop during in a two year. In the sowing norm was 2 kg ha^{-1}.70 kg ha^{-1} N and 50 kg ha^{-1} P_2O_5 fertilizer was applied. During growing period, the plants were irrigated average 3 times (after sowing, beginning of flowering and capsules formation). During the growing period, recommended pesticides and fungicides were applied to control insects and diseases. The remaining cultural practices were applied during the growing period.

The plants were harvested by hand and machinery at pre-maturity/full maturity with average of 4 day intervals. In the manual harvesting (H_2, H_4) the plants were pulled out with their roots and then 8-10 plants were bunched and bundled by hand. In semi-mechanized harvesting (H_1, H_3), the stems were cut by reaper-binder. They reached a certain diameter after which they were transferred onto the conveyor elevator behind the machine and left on the field. After the manual and semi-mechanized harvesting, the sheaves were let to dry on the field in stooks and overturned within 5-10 days and blended by thrashing with a cane.

The date of agricultural activity has given in Table 3.

Table 3. Experimental area sowing and harvest dates for main and second crop

Years	Agricultural activity	Main crop	Second crop
First year	Sowing	May 04	June 29
	H_1-H_2 (pre-maturity)	August 09	September 22
	H_3-H_4 (full-maturity)	August 12	September 26
Second year	Sowing	May 28	June 19
	H_1-H_2 (pre-maturity)	August 02	September 17
	H_3-H_4 (full-maturity)	August 06	September 21

2.1.Measurement and Assessment Methods

Oil and fatty acids were analyzed for data obtained sesame seed. *Oil percentage (%)*: It was determined at 0% humidity by NMR device operating according to nuclear magnetic resonance system. Oil ratio measurements were taken in two parallels from each plot and averaged (Anonymous 2014). *Ratio of fatty acids (oleic, linoleic, palmitic and stearic) (%)*: The amount of fatty acids indicated by gas-

liquid chromatography (7890A -mass detector - 5975C/FID Agilent) in extracted oil was determined in two parallel runs Fatty acid methyl esters of extracted oils were prepared (Anonymous 2014). Then, the mixture of prepared methyl esters was injected into the gas chromatography apparatus in a ratio of 40: 1, 10 µl. Helium was used as carrier gas. Fatty acid methyl esters A capillary column (HP Innowax Capillary; 60,0 m x 0,25 mm x 0,25 µm) was used for separation. Column temperature program from 150°C to 230°C. It is adjusted to rise with 2 minute and hold at 230°C for 10 minutes. Accordingly, the total analysis time was 50 minutes. Injection block and detector temperatures are both 250°C. Component percentages of the results were made with the FID detector, and the diagnosis of the components was made with the help of the fatty acid standards used and the MS detector. For this purpose, library data of WILEY7N, NIST05, OIL ADAMS were used (Anonymous 2014). The fatty acid ratios obtained at the end of the study were assessed according to the rates determined for sesame oil published in the Turkish-Food Codex Edible Oils Communiqué (Anonymous 2012) by the Ministry of Food, Agriculture and Livestock in 2007, taking into consideration the rates required for sesame oil. According to the Communiqué, the limit values for Palmitic, Stearic, Oleic and Linoleic fatty acids are given as 7,9-12,0%, 4,5-6,7%, 34,4-45,5% and 36,9-47,9% respectively and the sesame oils in this range were determined as high quality.

The collected data on different parameters were statistically analyzed to obtain the level of significance using JUMP 7.1.0 package program with randomize plot design. The means differences were compared with the Least Significant Differences (LSD, 5%) Test. Hypothesis tests were carried out on both 5% and 1% significance levels in the variance analysis.

3. Results and Discussions

There is an average of 4 days between H_1, H_2 (pre-maturity) and H_3, H_4 (full-maturity) of the subject harvests (Table 3).

3.1. Oil and Fatty Acids Composition

It was determined that the data for oil and fatty acid composition were statistically homogeneous in the trial in terms of years and analyses were carried out by combining the years. According to the multiple comparison analysis, there was no statistically significant difference between the subjects in terms of oil percentage in the main crop condition. On the other hand, the ratio of oil in semi-mechanized harvests (H_1, H_3) of second crops was statistically significant and varied at a 5% significance level (Table 4). It has been determined that the oil percentage obtained from mechanical harvesting of second crops condition with H_1 and H_3 subjects has an oil rate of 5.6% higher than that of manual harvesting on average.

Table 4. Summary of the variation from average fat ratio (%)

Parameters	Main crops conditional			Second crops conditional		
	First year	Second year	Average	First year	Second year	Average
H_1	58,11	54,64	56,38	54,94^{a}	56,04	55,49^{a}
H_2	56,03	55,76	55,89	52,64^{bc}	49,85	51,25^{b}
H_3	56,67	53,28	54,98	54,38^{ab}	55,48	54,93^{a}
H_4	57,30	56,08	56,69	51,83^{c}	54,72	53,28^{ab}
Average	**57,03**	**54,94**	**55,99**	**53,45**	**54,02**	**53,74**
CV(%)	2,37	7,53	5,96	2,48	5,81	4,58
LSD $_{(0.05)}$	-	-	-	2,12	-	2,54
P	ns	ns	ns	*	ns	*

Means followed by similar letters in columns or rows are not significantly different according to least significant difference (LSD).

** significant at 0.05 level of probability, respectively. ns: non significant; H_1: 'semi-mechanized harvest' during pre-maturity term; H_2: 'manual harvest' (traditional-1) during pre-maturity term; H_3: 'semi-mechanized harvest' during full maturity term; H_4: 'manual harvest' (traditional-2) during full maturity term*

It is reasoned that the cutting of the plant root system in the semi-mechanized harvest (H_1, H_3) causes the oil ratio to increase slightly by decreasing the drying time during the stooking period. In plants with manual harvesting methods left to dry (H_2, H_4), it is assumed that the continuing plant viability has a positive impact on the filling rate especially in the upper capsules. This might have decreased the oil ratio. Although a difference of 5% was determined in the significance level of the second crop, it was determined that the oil ratios of the subjects remained within the ratios indicated in the Turkish Food Codex Communiqué. An assessment of all the subjects revealed that the mean oil percentage of the main crop was 55,98% while the mean oil percentage of second crop products was 53,73%. It is argued that the total air temperature to which main and after crop products were exposed to had an impact on the oil ratio. When the two-year climatic data were evaluated, it was noted that the time in the field from sowing to harvesting was 98 days for main crops on average while the second crop remained in the field for 89 days. Uzun et al. (2002) reported that reduction or increase in fat rates is related to climate data. Also, Uzun et al. (2002) reported that sowing at a later date decreases the amount of oil. It is possible to say that the reduction oil ratio in the second crop. Haris et al. (2006) have reported that high temperatures accelerate the formation of oil and major constituents of oil. Dossa et al. (2018) reports that reduction or increase in oil and fatty acide rates is related to climate data. According to Dossa et al. (2018), samples from Africa sesame variety had higher oil and linoleic acid contents, while Asian samples had higher oleic content.

Table 5. Summary of the variation from average fatty acid ratio (%)

Parameters	**Main crops conditional**			**Second crops conditional**		
	1. year	2. year	Average	1. year	2. year	Average
Palmitic(C16:0)						
H_1	11,11	10,25	10,68	11,41	10,46	10,93
H_2	11,12	10,25	10,73	11,36	10,44	10,90
H_3	11,22	10,22	10,72	11,23	10,39	10,81
H_4	11,53	10,17	10,85	11,28	10,38	10,83
Average	11,25	10,22	10,75	11,32	10,42	10,87
CV(%)	2,3	1,9	2,1	3,1	2,2	2,2
Stearic (C18:0)						
H_1	6,56	5,54	6,05	7,44	6,08	6,76
H_2	6,81	5,71	6,26	7,37	6,18	6,78
H_3	6,70	6,03	6,36	7,40	5,93	6,66
H_4	6,87	6,01	6,44	7,33	5,93	6,63
Average	6,74	5,82	6,28	7,39	6,03	6,71
CV(%)	2,6	7,3	5,2	3,1	2,6	2,9
Oleic (C18:1)						
H_1	40,71	41,12	40,92	40,57	40,98	40,77
H_2	40,56	41,10	40,83	40,51	40,61	40,56
H_3	40,86	41,49	41,17	40,12	40,76	40,44
H_4	40,70	41,32	41,01	40,12	40,33	40,22
Average	40,70	41,25	40,98	40,33	40,67	40,49
CV(%)	1,0	1,1	1,1	1,1	0,8	0,9
Linoleic (C18:2)						
H_1	40,02	41,55	40,78	38,90	41,10	40,00
H_2	39,57	41,43	40,50	38,81	41,20	40,01
H_3	39,47	41,49	40,48	39,37	41,45	40,41
H_4	38,99	41,31	40,15	39,38	41,46	40,57
Average	39,51	41,45	40,48	39,12	41,30	40,25
CV(%)	1,5	1,2	1,3	1,2	1,2	1,2
P value						
Palmitic(C16:0)	ns	ns	ns	ns	ns	ns
Stearic(C18:0)	ns	ns	ns	ns	ns	ns
Oleic(C18:1)	ns	ns	ns	ns	ns	ns
Linoleic(C18:2)	ns	ns	ns	ns	ns	ns

ns: non significant; H_1: 'semi-mechanized harvest' during pre-maturity term; H_2: 'manual harvest' (traditional-1) during pre-maturity term; H_3: 'semi-mechanized harvest' during full maturity term; H_4: 'manual harvest' (traditional-2) during full maturity term

There was no statistically significant difference in the composition of palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$) and linoleic ($C_{18:2}$) fatty acids in the main crop and second crop product conditions (Table 5). A high ratio of oleic ($C_{18:1}$) and linoleic ($C_{18:2}$) fatty acids is desirable in terms of quality. According to the Turkish-Food Codex Edible Oils Communiqué (2012) published by the Ministry of Food, Agriculture and Livestock sesame oil should contain palmitic (C16:0), stearic (C18:0), oleic ($C_{18:1}$) and linoleic ($C_{18:2}$) fatty acids in percentages of 7,9-12,0%, 4,5-6,7%, 34,4-45,5%, and 36,9-47,9% respectively. An assessment of the data for two years revealed that the oil acidity ratios in the main crop conditions were 10,74%, 6,27%, 40,98% and 40,47%, on average respectively, and while the figures for second crop conditions were 10,86%, 6,70%, 40,49% and 40,24%, respectively. It was concluded that the fatty acid values in main crop and second crop conditions were within the border limits of the Turkish-Food Codex.

The absence of statistical significance and lack of effect on a significant level in terms of fatty acid composition for main crop and second crop product conditions can be interpreted as the difference in harvest dates being insignificant in affecting oil acid composition. In fact, an examination of this data indicates that the average oil acid compositions of main and second crop products are actually very close to each other. There are 4 days between mechanized pre-maturity harvesting (H_1) and full maturity harvesting (H_3) on average. The same situation is valid for manual harvesting (H_2, H_4). It is not possible to increase this interval because a longer waiting period for the plant means increasing yield losses. Taking this result into consideration, it has been determined that products of the same quality can be obtained from semi-mechanized harvesting (H_1, H_3) and traditional manual harvesting (H_2, H_4). Bhunia et al. (2015) reported that the percentage of oleic acid varied between 38 and 50%, and that linoleic acid ranged from 18 to 43%. Kurt (2018) reported that palmitic and stearic acids were in the range of 8,19 to 10,26% and 4,63 to 6,35%, respectively. Similar results were determined that palmitic and stearic acids were found in our study between 11,53-10,17% and 6,87-5,57%, respectively.

Oil content and fatty acid composition are important quality characteristics in sesame seed. But, these factors were not affected by hand or semi-mechanized harvesting methods.

4. Conclusion

It was observed that there were no differences in the composition of oil and fatty acids between semi-mechanized harvesting and manual harvesting. It has been determined that sesame, without roots (semi mechanized methods), has no negative effect on the quality of the product. Furthermore, it was determined semi-mechanized harvesting in second product conditions has a positive impact on oil ratio of 5.6%. From this perspective it is detected reaper-binder (semi-mechanized method) could be practicable for sesame harvesting.

5. References

Adil, A. and Ahmed, H.Y., 2015. The Economics of Sesame Production in Gadarif Mechanized Rainfed Sector. MSc. thesis. Univrsity of Khartoum, Sudan.

Ahmad, A. and Abdin, Z.M., 2000. Effect of Sulphur Aplplication on Lipid, RNA and Fatty Acid Content in Developing Seed of Rapeseed. Plant Science, 150: 71-76

Anonymous, 2012. Türk Gıda Kodeksi. www.aso.org.tr (Accessed 12.02.2007).

Anonymous, 2014. Türk Gıda Kodeksi Zeytinyağı ve Pirina Yağı Analiz Metotları Tebliği. Tebliğ No: 2014/53. Resmi Gazete, Sayı: 29181.

Ashri, A., 2007. Sesame (*Sesamum indicum* L.). In: Genetics Resources, Chromosome Engineering and Crop Improvement, Oilseed Crops, Vol.4, ed. Singh R.J., 231-289, CRC Press, Boca Raton

Baydar, H., 2000. Bitkilerde Yağ Sentezi. Kalitesi ve Kaliteyi Artırmada Islahın Önemi. Ekin Dergisi. 11: sf: 50-57

Bhunia, R.K., Chakraborty, A., Kaur, R., Gayatri, T., Bhat, K.V., Basu, A., Maiti, M.K. and Sen, S.K., 2015. Analysis of Fatty Acid and Lignan Composition of Indian Germplasm of Sesame to Evaluate Their Nutritional Merits. J. Am. Oil Chem. Soc. 92(1): 65-76 DOI: 10.1007/s11746-014-2566-3

Dataem, 2017. Doğu Akdeniz Tarımsal Araştırma Enstitüsü Müdürlüğüne ait İklim Verileri. www.cukurovataem.gov.tr (Accessed 01.02.2017).

Dwivedi, S., Nigam, S.N., Nagswara., R., Singh, U. and Rao, K.V.S., 1996. Effect of Drought on Oil, Fatty Acids and Protein Contents of Grounnut Seed. Field Crops Research, 48: 124-133

Dubey, S.D., Husain, K. and Vajpeyi, M., 2001. Yield and Quality of Linseed under Saline Condition. Indian Journal Agricultural Biochemical, 14 (1&2): 75-76

Dossa, K., Wei, X., Niang, Mareme, Liu P., Zhang, Y., Wang, L., Liao, B., Cisse, N, Zhang, X. and Diouf, D., 2018. Near-Infrared Reflectance Spectroscopy Reveals Wide Variation İn Major Components of Sesame Seeds From Africa and Asia. The Crop Journal Volume 6, Issue 2, pp 202-206

Georgiev, S., Stamatov, S. and Deshev, M., 2008. Requirements to Sesame (*Sesamum indicum* L.) Cultivars Breeding For Mechanized Harvesting. Bulgarian Journal of Agricultural Science 14:616-620.

Gharby, S., Harhar, H., Bouzoubaa, Z., Asdadi, A., El Yadini, A. and Charrouf, Z., 2018. Chemical Characterization and Oxidative Stability of Seed and Oil of Sesame Grown in Morocco. Journal of Saudi Socienty of Agricultural Sci. Vol 6 (2): 105-111. https://doi.org/10.1016/j.jssas.2015.03.004

Hwang, L.S., 2005. Sesame oil. In Bailey's Industrial Oil and Fat Products, 6th ed.; Shahidi, F., Ed.; John Wiley and Sons Inc.: New York, NY, USA, pp. 538–577. ISBN 047167849X

Haris, H.C., Mc William, J.R. and Mason, W.K., 2006. Influence of Temperature on Oil Content and Composition of Sunflower Seed. Australin Journal of Agricultural Research, 29(6): 1203-1212

Flagella, Z., Royunno, T., Tarantino, E., Caterina, A. and De Caro, A., 2002. Changes in Seed Yield and Oil Fatty Acid Composition Of High Oleic Sunflower Hybrids in Relation To The Sowing Date and Woter Regime. Europan Journal of Agronomy, 17: 221-230

Karaca, E. and Aytac, S., 2007. The Factors Affecting on Fatty Acid Composition 0f Oil Crops. J. of Fac. of Agric., OMÜ, 2007, 22(1): 123-131.

Kurt, C., 2018. Variation in Oil Content And Fatty Acid Composition of Sesame Accessions from Different Origins. Grasas Y Aceıtes 69 (1) January–March 2018, e241 ISSN-L: 0017-3495 https://doi.org/10.3989/gya.0997171

Langham, R., 1985. USA- Growing Sesame in the Desert Soutwest. Sesame and Sunflower: Status and Potentials. FAO. Paper no: 66 Rome. p: 75-79.

Langham, D.R. and Wiemers, T., 2002. Progress in Mechanizing Sesame İn US Through Breeding. In : Janick, J. And Whipkey, A.(eds.) Ternd in New Crops and New Uses. American Society for Horticultural Scince Press, Alexandria, VA.157-173

Mondal, N., Bhat, V.K. and Srivastava, S.P., 2010. Variation in Fatty Acid Composition in Indian Germplasm of Sesame. J. Am. Oil Chem. Soc. 87, 1263–1269. https://doi.org/10.1007/s11746-010-1615-9

Nobre, D.A.C., Trogello, E., Morais, D.L.B. and e Brandão Junior, D.S., 2013. Qualidade da Semente do Gergelim Preto (*Sesamum indicum* L.) em Diferentes Epocas de Colheita. Revista Brasileira de Plantas Medicinais 15:609-616.

Uğurluay, S., 2002. A Research On Determination of Harvesting Mechanization Possiblities of Sesame Plant. Çukurova Uni. Deparment of Agricultural Machinery Instıtute of Natural and Applied Sciences.Number: 119859

Uzun, B., Ulger, S. and Çağırgan, M.N., 2002. Comparison of Determinate and Indeterminate Types of Sesame for Oil Content and Fatty Acid Composition. Turk J Agric For 26 (2002) 269-274

Tripathy, S.K., Kar, J. and Sahu, D., 2019. Advances in Sesame (*Sesamum indicum* L.) Breeding. In Advances in Plant Breeding Strategies: Industrial and Food Crops; Al-Khayri, J.M., Jain, S.M., Johnson, D.V., Eds.; Springer: Cham, Switzerland; pp. 577–635.

Vurarak, Y., Angın, N. ve Bilgili, E.M., 2014. Çukurova Koşullarında Biçerbağların Ana ve II. Ürün Susam Hasadında Kullanılabilirliğinin Araştırılması. Gıda, Tarım ve Hayvancılık Bakanlığı Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü, Sonuç Raporu. TAGEM/10/05/01/004, yayın No: 12.01DATAEM.N.N20/2014/01

Queiroga, V.P., Gondim, T.M.S. and Queiroga, D.A.N., 2009. Tecnologias Sobre Operações de Semeadura e Colheita Para a Cultura do Gergelim (*Sesamum indicum* L.) Revista Agro Ambiente 3:106-121.

Weiss, E. A., 1971. Castor, Sesame and Sunflower; Barnes & Noble: New York, NY, USA.