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EFFECTS OF DIFFERENT STORAGE PERIOD ON GERMINATION AND SOME QUALITY PROPERTIES OF SAFFLOWER SEEDS (*Carthamus tinctorius* L.)

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Abstract
In this study, effects of the storage periods (12, 24, 36, 48 and 60 months) on germination and some quality traits of different safflower (Carthamus tinctorius L.) cultivars (Dinçer, Balcı, Yenice and Remzibey), one of the alternative raw materials in the vegetable oil industry, have been investigated. For this purpose, seeds from the 2014, 2015, 2016, 2017 and 2018 growing season were stored at + 4 ° C. In the study germination percentage, days to germination, oil content, protein content, linoleic and oleic acid content were investigated. According to the study result, all characters were found to be significant statistically (P<0.05) in terms of storage period. It was determined that as the storage period increased, the germination percentage of safflower seeds decreased and the highest germination percentage was obtained from the 12 months storage period (93.33%). Balcı cultivar has showed the highest oil content (34.54 %) 24 months of storage period. When this study is examined as a whole, it is conclusioned that safflower seeds must be processed in a short time after the harvest; otherwise, there will be losses in germination power and quality of seeds as the storage period increases.

Keywords: germination, safflower, storage period, quality

1. INTRODUCTION

Safflower (*Carthamus tinctorius* L., Asteraceae) is an annual oilseed crop that is adapted to hot and dry environments (Li and Mundel, 1996). About 690 000 tons of safflower seeds are produced in an area of 840 835ha worldwide (Anonymous, 2017). Turkey is 35 000 tons of safflower seeds are produced in about 25 000 ha area in 2018 (Anonymous, 2018). Turkey is dependent on other countries for production of oilseed crops. In 2016, plant crude oil was produced 780 000 tonnes, it was imported1 482 000 tonnes in Turkey and this production met nearly 34 % of our needs (Anonymous, 2016). Thus, research on alternative oil crops has continued recently in order to resolve vegetable oil deficit.

Safflower is one of the alternative oil crops. As safflower is unselective in terms of ecological conditions and more resistant to lower temperatures than other oil crops, this provides a production area in different climates for the safflower (Arslan and Culpan, 2018). On the other hand drought resistant and cultivation without irrigation enable especially availability of fallow areas (Culpan and Arslan, 2017). Safflower will become one of the oil crops which have the potential to resolve vegetable oil deficit in our country. However, the oil content and seed yield of safflower are lower than other oil crops (sunflower, canola etc.).

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Seed aging during storage is an inevitable phenomenon, but the degree and speed of decline in seed quality depend strongly, beside storage conditions, on plant species stored and initial seed quality (Elias and Copeland, 1994; Balesevic et al., 2005).
Storage conditions and period have large influence on the quality of oil seeds. Storage period of oil seeds before oil extraction might effect the quality of the crude oil (Martini and Anon, 2005).Storage is done to maintain harvesting quality of product not to improve it (Şişman and Delibaş, 2004).According to Şişman and Delibaş (2004) and Şişman (2005) during storage period the oil content of sunflower (*Helianthus annuus*L.) decreased progressively. Villiers et al., (1986) indicated that highstorage temperature and humidity had significant effect on sunflower seed oil quality.
Öztürk and Mengüloğlu indicated that oil content of sunflower seeds have decreased linearly during the storage period. Martini and Anon (2005) reported that during storage of sunflower seed indifferent temperature the oil content did not influence.
The aim of this study was to determination of effects the different storage period on germination and some quality traits of safflower seeds.

2. MATERIALS AND METHODS

In this study, five storage periods (12, 24, 36, 48 and 60 months) were determined and four safflower cultivars were used as the plant material. Local cultivars of Yenice, Remzibey, Dinçer and Balcı were obtained from Transitional Zone Agricultural Research Institute. For this purpose, seeds from the 2014, 2015, 2016, 2017 and 2018 growing season were stored in the refrigerator. Refrigerator temperature was+ 4 ° C and humidity 60%.
To investigate the effect of storage periods on germination of safflower seeds, a laboratory experiment was conducted in August, 2019 at the Department of Field Crops, Namık Kemal University. The experiment was arranged in completely randomized design with three replications. Local cultivars of Yenice, Remzibey, Dinçer and Balcı were carried out with five of storage periods (12, 24, 36, 48 and 60 months) for the experiment, deionized water was used for germination. Twenty safflower seeds were uniformly placed per Petri dish (9.5 cm diameter) using a forceps after the Petri dish were sterilized and rinsed with deionized water. All the petri dishes were covered with lids and kept at room temperature (24 ± 2 ^{o}C). Germination continued for 7 days, and germinated seeds were counted daily. Germination was considered to have occurred when radicles attained a length of 2 mm. After 7 days, germination was calculated according to ISTA (1999). Germination percentage was calculated according to the following formulas.

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total Number of seeds kept for germination}} \text{ X } 100$$

In the study germination percentage (%), days to germination, oil content (%), protein content (%), linoleic and oleic acid content (%) were investigated. Results was analyzed using TARIST and MSTAT-C (MSTAT, 1989) statistical software for analysis of variance. Least Significant Difference (LSD) test was used to compare the means of the obtained results in this research ($p < 0.05$).

3. RESULTS AND DISCUSSIONS

Germination percentage (%)

Results showed that the percentage of germination decreases as storage period increases and the lowest germination percentage obtained from 60 months storage period with Balcı and Remzibey

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cultivars (20 %) (Table 1).The increase of storage period resulted in decline in ability of seeds to germinate.

Table 1. The effects of different storage period on germination percentage (%)

Cultivar	**Storage Period**					**Means**
	2014 (60 months)	2015 (48 months)	2016 (36 months)	2017 (24 months)	2018 (12 months)	
	Cultivar x Storage Period Interactions					
Dinçer	38.33 **f**	51.67 **de**	68.33 **c**	83.33 **b**	96.67 **a**	67.67 **ab**
Balcı	20.00 **g**	50.00 **de**	53.33 **de**	83.33 **b**	95.00 **a**	60.33 **bc**
Yenice	50.00 **de**	58.33 **d**	70.00 **c**	83.33 **b**	93.33 **a**	71.00 **a**
Remzibey	20.00 **g**	46.67 **ef**	51.67 **de**	68.33 **c**	88.33 **ab**	55.00 **c**
Means	32.08 **e**	51.67 **d**	60.83 **c**	79.59 **b**	93.33 **a**	63.50
$LSD_{0,05}$	Cultivar: 8.662, Storage Period: 4.618, Cultivar x Storage Period Interactions: 9.235					

Means followed by the same letter within columns are not significantly different at the level of $p < 0.05$

Many researchers emphasized that as the storage period increased, the germination percentage of seeds decreased (Genes and Nyomora, 2018; Mishra et al., 2016; Maity et al., 2000). Petrenko (2014), reported that the optimal storage period for winter wheat seeds under different conditions was 6-18 months, otherwise, germination power decreases as storage time increases. This result is associated with our results.

Days to germination

The results of the variance analysis showed that significant effect storage period on days to germination were at a level one percent ($p < 0.01$).The results of storage period means showed that the highest days to germination obtained from 60 months storage period with 6,83 days (Table 2).

Table 2. The effects of different storage period on days to germination

Cultivar	**Storage Period**					**Means**
	2014 (60 months)	2015 (48 months)	2016 (36 months)	2017 (24 months)	2018 (12 months)	
	Cultivar x Storage Period Interactions					
Dinçer	7.33	6.33	5.33	4.67	3.67	5.47
Balcı	7.33	7.00	6.00	5.00	3.67	5.80
Yenice	6.00	6.33	6.00	5.67	4.00	5.60
Remzibey	6.67	6.00	5.33	4.00	3.67	5.13
Means	6.83 **d**	6.42 **d**	5.67 **c**	4.83 **b**	3.75 **a**	5.50
$LSD_{0,05}$	Storage Period: 0.598					

Means followed by the same letter within columns are not significantly different at the level of $p < 0.05$

The results showed that number of days of germination increases as the seeds aged.

Oil Content (%)

The results of the variance analysis showed that significant effect cultivars, storage period and also the interaction between cultivar and storage period on oil content were at a level 1 % ($p<0.01$). The

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results of cultivars means showed that the highest oil content obtained from cultivars Balcı, Remzibey and Dinçer (32.96%, 32.24% and 31.64% respectively). The results of storage period means showed that the highest oil content obtained from 12 and 24 months storage period (31.79% and 32.06% respectively) (Table 3).

Interactions between cultivar and storage period the highest oil content were obtained in Balcı cultivar with 24 months storage period (34.54%) (Table 3). Öztürk and Mengüloğlu indicated that oil content of sunflower seeds have decreased linearly during the storage period. According to Şişman (2005) during storage period the oil content of sunflower (*Helianthus annuus* L.) decreased progressively. Suriyong (2007) also reported that the ageing process naturally affects the quality of seeds during storage at various conditions; especially the oil content. This result is associated with our results.

Table 3. The effects of different storage period on oil content (%)

Cultivar	**Storage Period**					**Means**
	2014 (60 months)	2015 (48 months)	2016 (36 months)	2017 (24 months)	2018 (12 months)	
	Cultivar x Storage Period Interactions					
Dinçer	28.02 **d**	31.29 **c**	32.81 **b**	33.01 **b**	33.08 **b**	31.64 **a**
Balcı	31.39 **c**	31.44 **c**	33.69 **ab**	34.54 **a**	33.76 **ab**	32.96 **a**
Yenice	26.00 **e**	26.62 **e**	26.58 **de**	27.15 **de**	27.14 **de**	26.70 **b**
Remzibey	30.33 **c**	30.71 **c**	33.43 **ab**	33.56 **ab**	33.16 **b**	32.24 **a**
Means	28.94 **c**	30.01 **b**	31.63 **a**	32.06 **a**	31.79 **a**	30,88
$LSD_{0,05}$	Cultivar: 1.526, Storage Period: 0.623, Cultivar x Storage Period Interactions: 1.244					

Means followed by the same letter within columns are not significantly different at the level of $p < 0.05$

Protein Content (%)

The results of variance analysis showed that significant effect cultivar ($p<0.01$), and also the effect of the storage period on protein content were at a level 5 % ($p<0.05$). The results of cultivars means showed that the lowest protein content obtained from cultivar Yenice (12.99%) (Table 4). The results of storage period means showed that the highest protein content obtained from 24 months storage period (14.09%) (Table 4).

Table 4. The effects of different storage period on protein content (%)

Cultivar	**Storage Period**					**Means**
	2014 (60 months)	2015 (48 months)	2016 (36 months)	2017 (24 months)	2018 (12 months)	
	Cultivar x Storage Period Interactions					
Dinçer	13.70	13.66	14.25	14.59	14.21	14.08 **a**
Balcı	13.86	14.07	14.15	14.48	14.04	14.12 **a**
Yenice	12.90	12.90	12.80	13.35	12.99	12.99 **b**
Remzibey	13.81	13.71	13.90	13.95	13.88	13.85 **a**
Means	13.57 **b**	13.59 **b**	13.78 **ab**	14.09 **a**	13.78 **ab**	13.76
$LSD_{0,05}$	Cultivar: 0.438, Storage Period: 0.319					

Means followed by the same letter within columns are not significantly different at the level of $p < 0.05$

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Linoleic Acid Content (%)

The results of the variance analysis showed that significant effect cultivars, storage period and also the interaction between cultivar and storage period on linoleic acid content were at a level 1 % ($p<0.01$).The results of cultivars means showed that the highest linoleic acid content obtained from cultivar Yenice (79.61%) (Table 5).Interactions between cultivar and storage period the highest linoleic acid content were obtained in Balcı cultivar from 36 and 60 months storage period (80.02% and 80.00% respectively) (Table 5).

Table 5. The effects of different storage period on linoleic acid content (%)

Cultivar	**Storage Period**					**Means**
	2014 (60 months)	2015 (48 months)	2016 (36 months)	2017 (24 months)	2018 (12 months)	
	Cultivar x Storage Period Interactions					
Dinçer	75.00 **ı**	74.95 **j**	74.89 **k**	74.95 **ıj**	75.41 **h**	75.04 **c**
Balcı	76.74 **f**	76.80 **e**	76.66 **g**	76.72 **f**	77.04 **d**	76.79 **b**
Yenice	80.00 **a**	79.92 **b**	80.02 **a**	79.97 **ab**	78.12 **c**	79.61 **a**
Remzibey	56.13 **o**	56.59 **l**	56.42 **m**	56.33 **n**	55.53 **p**	56.20 **d**
Means	71.97 **c**	72.07 **a**	72.00 **b**	71.99 **bc**	71.53 **d**	71.91
$LSD_{0,05}$	Cultivar: 0.027, Storage Period: 0.028, Cultivar x Storage Period Interactions: 0.020					

Means followed by the same letter within columns are not significantly different at the level of $p < 0.05$

Safflower is reported to be the best example of a crop with variability for fatty acid composition in seed oil (Knowles, 1989).During storage, products especially stored oils compositions can be influenced by several storage conditions (Azhari et al., 2008). Therefore, both linoleic acid and oleic acid compositions differed in terms of storage period.

Oleic Acid Content (%)

The results of the variance analysis showed that significant effect cultivars, storage period and also the interaction between cultivar and storage period on oleic acid content were at a level 1 % ($p<0.01$).Interactions between cultivar and storage period the highest oleic acid content were obtained in Remzibey cultivar from 12 months storage period (34.46%) (Table 6).

Table 6. The effects of different storage period on oleic acid content (%)

Cultivar	**Storage Period**					**Means**
	2014 (60 months)	2015 (48 months)	2016 (36 months)	2017 (24 months)	2018 (12 months)	
	Cultivar x Storage Period Interactions					
Dinçer	14.25 **e**	14.23 **e**	14.05 **g**	14.16 **f**	13.90 **h**	14.12 **b**
Balcı	13.56 **k**	13.55 **k**	13.65 **j**	13.85 **ı**	13.23 **k**	13.63 **c**
Yenice	11.37 **n**	11.49 **lm**	11.46 **m**	11.51 **l**	10.99 **o**	11.36 **d**
Remzibey	33.85 **c**	33.91 **b**	33.63 **d**	33.82 **c**	34.46 **a**	33.93 **a**
Means	18.26 **c**	18.29 **b**	18.19 **d**	18.33 **a**	18.22 **d**	18.26
$LSD_{0,05}$	Cultivar: 0.022, Storage Period: 0.026, Cultivar x Storage Period Interactions: 0.016					

Means followed by the same letter within columns are not significantly different at the level of $p < 0.05$

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4. CONCLUSIONS

The oil content decreases as the moisture content increases in oil seeds. The high humidity of the refrigerator (60%) may have reduced the oil content of the safflower seeds.Also oilseed species, its seeds lose their germinating power far more quickly, especially when stored under unsuitable conditions. Therefore, oilseeds should be used in scientific studies without waiting too long.

When this study is examined as a whole, it is conclusioned that safflower seeds must be processed in a short time after the harvest; otherwise, there will be losses ingermination powerand quality of seeds as the storage period increases.

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