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Temporary Sunflower Seed Stores and Quality Losses During Storage

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Abstract: The aim of storage is to preserve properties of products and their freshness. If suitable storage conditions aren't supplied according to product variety, quality and quantity losses increase. Decreasing this losses is possible with providing suitable storage condition and storage management. In this study, temporary sunflower storage buildings in the Thrace Region were examined to investigate the influences of storage condition on product quality losses. The study was conducted in one of the Trace Union's temporary store and a model store having aeration system built specifically for this research in Tekirdag Agricultural Faculty's area. Temperature and relative humidity of the sunflower mass as storage conditions in the stores and moisture content due to its effect on quality parameters, oil content and free fatty acids contents as quality parameters were monitored during the storage. Results showed that storage conditions in the temporary store doubled the quality losses when compared with the model store.

Key words: Storage, sunflower, temporary storage, storage conditions, quality losses

INTRODUCTION

Because of the nourishment necessity of population in the world, sources in the world must be used economically. Recently, increased farm production based on obtaining more product from a unit area. However processing and evaluating of these products are more important. Majority of farm products are consumed after the process. Hence, storage of products after the process until marketing is a necessity. The aim of the storage is to preserve properties of products and their freshness until marketing or consuming. If suitable storage conditions are not supplied according to product variety, quality and quantity, losses increase.

Majority of oil which is most important food for human because of high energy are vegetable origin (86%). Sunflower in the oil plants leads due to 25-50% oil content. Approximately 12.6% of vegetable oil production in the world is covered by sunflower[1].

Turkey is 9th largest sunflower producer in the world with the average of 843 000 t from 578 000 ha farm area. An important part of sunflower production (60%) in Turkey (500 000 t) is produced in Thrace region[2].

Majority of sunflower produced in the Thrace Region (70%) are stored in temporary stores. Because these stores are very sensitive to weather condition, losses during storage are economically very important. Using temporary stores widespreadly in this region leads to losses of approximately 10 million US $ per year[3].

The objective of this study is to investigate the present state of temporary sunflower storage in Thrace Region, to identify the reason effective for the quality losses during storages and suggest suitable storage conditions to minimize the losses.

MATERIALS AND METHODS

The study was carried out in one of the store of Thrace Union, which is the state oil production company in Tekirdag, Yagci Village temporary store and a model store built specifically for this research in the Agricultural Faculty's area. Sunflower seeds were collected from these stores every month regularly during nine-month storage period started from September 2001 and all analysis were done on these samples.

Temporary sunflower store in Yagci village was settled up in East-West direction. This store was 180 m in length, 10 m in width, 1,3 m in height the wall and 3.6 m in height. During its construction, first soil was compressed, drainage ditches were opened at side of the store and a nylon canvas was spread over the soil. 1.3 m height store walls were formed by stacking sacks full of sunflower one on the top of the other. Sunflowers seeds were heaped between the walls and covered with canvas

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and then it was tied firmly. Sunflower seeds having 6% moisture content and 3% foreign material were placed in this store harvested in 2001.

A model store having an aeration system and 2 m^3 capacity was built and the quality losses in this store were compared to the losses occurred in the temporary store in the region. The floor of the model store was concrete, walls were bricks and plaster and it was cover by canvas. The aeration in the store was done using two ducts systems on the floor having 1.5x 0.1 m cross sectional area as suggested by Hellevang[4] and Proctor[5]. Air flow was supplied with a fan having 0.3 m^3/min capacity per 2 m^3 crop and having 0.2 m diameter as proposed by Hellevang[4], Hall[6], Cloud and Morey[7], Bloome *et al.*[8], Hofman and Hellevang[9], Harner *et al.*[10]. The size of the open area in the roof was 0.75 m^2 (cross sectional area) as recommended by Hellevang[4], Proctor[5] and Bloome *et al.*[8]. 830 kg sunflower having 6% moisture content and 3% foreign material was placed in this store. Mass temperature and relative humidity into the stores as storage conditions and moisture content due to its effect on quality criteria, oil content and free fatty acidity as sunflower quality criteria were determined on the sample collected from each stores during the storage. 2x4x10 factorial experimental design as randomized plot design was applied[11] . Factors in this design were the two stores, four locations and the ten months storage period.

Measurements of mass temperature and relative humidity in the stores were recorded using a digital humidity/temperature meter recorder on weekly basis as triple replicated at four different points of each stores as recommended by Harrier[12], Thompson and Shelton [13], Noyes *et al.*[14], Harner and Hellevang[15]. Temperature and humidity measurements were done in tree replications from the center and side of the stores and also at two different depths, at 25 and 75% of the mass depth. The humidity and temperature sensors was placed 0.5 m apart from the side walls for temporary store and 0, 25 m for model store.

Weather temperature and relative humidity were measured by a termohydrograph and these records regulated when to operate the aeration system in the model store. Aeration was operated as soon as the air temperature was 8°C cooler than that of the mass and was continued until the temperatures became equal. Aeration system was also shut and covered when the relative humidity exceeded 75% and during the rainy period[4,7,12,15].

Sunflower samples were taken every month regularly in the stores to determine the losses occurred in the stores during storage period. The samples were taken in tree replications from the center and side of the stores and at two different depths, 25 and 75% of the mass depths according to Turkish Standards no 163 related to Taking Sample from Oil Seed (Turkish Standard Institute, 1980)[16]. Partitioned hand probe was used for taking samples.

Analyzes of moisture content, oil content and free fatty acidity in the laboratory were done on the samples. Moisture contents were determined on basis of dry weight[17]. To determined the oil contents Soxheled method, which adjust oil content to a constant moisture, (IUPAC method no: 1.122) was used (Free fatty acidity was determined using titratable acidity in IUPAC method no: 2.201[18].

The results obtained were evaluated using SPSS and MSTAT computer programs for Variance analysis and Duncan tests.

RESULTS AND DISCUSSION

Storage conditions: Changes in the average temperatures and humidities during the storage period were presented in Table 1 and 2 for temporary and model stores, respectively.

As seen in Table 1, in general, mass temperature in the temporary store varied parallel to changing weather temperature. Mass temperature decreased in the autumn and it increased in the spring. Decreasing mass temperature in the autumn was quicker in the sides of the store when compared with the bottom middle part as explained by Hellevang[4], Proctor[5], Hofman and Hellevang[9], Brooker *et al.*[19], Hellevang[20]. In the spring, mass temperature begun to increase due to not only the increase in the weather temperature but also the crop respiration, insect activity and crop deterioration from March. As expected in this period, the sides and upper part of the mass warmed up quickly. Temperature variation in this store was formed during cooling and warming and this difference caused to moisture migration[5,9,19,20].

The decreases in the weather temperature lead to decrease also in the mass temperature, which in turn, increase in mass humidity in the temporary store during autumn. In this period, the humidity in upper part of the mass increased more than the bottom due to moisture migration. Mass humidity in the spring decreased slightly in windy days and low relative humidity days, but it rose again because of crop respiration.

Mass temperature in the model store coincided with the changing in weather temperature, it decreased in autumn and increased in spring. Generally mass temperature in the model store were maintained below 17°C as recommended by Hellevang[4], Cloud and Morey[7], Brooker *et al.*[19] and Navarro[21] for optimum storagein terms of insect control as a result of aerating 220 h during

Table 1: Recorded in temperatures and humidities in the temporary store during the storages

Temporary store date	Temperature					Humidity				
	Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Out side	Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Out side
05/09/01	38.15	34.10	36.45	33.80	22.90	68.15	75.05	74.75	78.55	69.60
11/09/01	35.90	36.90	31.75	32.65	22.10	75.50	72.40	69.50	72.45	64.00
16/09/01	33.70	35.75	29.80	30.50	20.10	75.00	72.65	68.80	67.85	70.20
22/09/01	33.50	34.95	30.20	29.90	22.50	76.30	77.70	69.55	70.60	73.30
29/09/01	29.65	32.20	25.60	26.70	20.70	96.95	95.05	90.80	90.65	74.10
05/10/01	32.10	33.75	30.75	30.15	16.00	86.85	87.70	79.65	77.00	80.00
12/10/01	21.55	23.20	17.30	16.50	13.30	87.10	88.00	84.75	82.50	77.10
18/10/01	25.70	28.75	24.45	25.40	16.60	88.20	85.10	86.25	85.55	68.30
26/10/01	21.90	25.30	19.65	21.10	11.30	85.40	89.60	92.05	91.05	73.20
06/11/01	16.85	19.25	15.55	16.50	8.60	92.50	94.20	94.85	95.20	77.70
15/11/01	16.20	18.90	16.85	18.00	11.40	90.05	93.45	93.55	94.85	73.80
22/11/01	17.95	20.65	17.30	19.50	6.14	90.55	92.80	96.10	95.60	73.90
29/11/01	15.25	17.00	14.75	15.70	4.00	95.75	95.00	97.90	95.50	79.00
05/12/01	1.85	9.75	1.30	2.30	0.20	98.25	98.65	98.50	98.90	85.00
12/12/01	-1.60	7.70	-2.80	-2.10	-2.70	98.05	99.30	99.25	99.20	80.80
25/12/01	1.95	9.45	1.15	1.80	-2.40	98.10	98.20	98.65	97.90	85.20
04/01/02	0.95	2.20	-0.20	1.15	-0.40	97.85	97.65	99.35	98.60	81.00
18/01/02	5.35	7.65	4.35	6.55	1.50	98.85	98.95	98.95	98.80	82.80
30/01/02	14.70	12.25	14.30	15.55	3.90	93.55	90.50	94.25	97.15	83.40
16/02/02	11.80	12.25	12.10	14.45	4.60	97.85	98.25	98.65	98.15	77.80
03/03/02	14.75	15.60	15.20	16.00	6.80	97.15	97.65	97.50	98.25	79.80
09/03/02	21.05	20.10	21.50	21.30	10.10	95.15	92.85	93.65	89.60	62.50
19/03/02	27.65	28.50	23.40	24.90	8.70	97.85	97.80	96.45	96.80	79.90
26/03/02	27.35	28.40	27.95	29.95	9.50	97.90	97.70	96.80	97.25	84.40
01/04/02	27.85	28.95	30.45	30.60	5.80	97.85	97.75	98.00	96.60	80.10
10/04/02	29.35	32.45	34.15	32.85	7.80	98.45	97.60	98.80	98.30	71.40
16/04/02	29.15	33.05	34.20	33.30	10.60	98.30	97.90	98.85	97.95	84.00
25/04/02	30.50	34.15	36.35	37.85	11.10	97.95	98.70	98.50	93.95	62.20
05/05/02	39.35	42.00	40.05	39.60	14.00	98.45	97.20	98.45	92.80	75.20
13/05/02	40.75	42.85	40.85	40.00	15.20	98.55	97.60	98.10	97.80	71.50
17/05/02	40.40	42.95	41.25	40.80	16.50	98.35	98.00	98.00	98.35	56.50
24/05/02	40.00	43.25	39.75	40.45	17.70	96.50	96.90	95.10	94.15	66.80
04/06/02	42.15	44.00	42.00	42.50	19.70	95.95	96.65	94.65	93.40	69.40

autumn and 125 h during spring. Because of aeration (total 345 h), temperature differences occurred between the zones in the store were not significant and homogenous temperature distribution in the model store was supplied. Therefore moisture migration in the store in great extend was prevented.

Mass humidity in the model store decreased by aeration during first month of storage, but afterwards, when aeration was stopped, it increased again. Mass humidity did not change since the aeration was not operated and it remained around 80%. When the aeration was operated during spring, mass humidity decreased while it increased in rainy period.

In this part, temperature and humidity values were evaluated statistically one by one, in order to determined differences between the stores (Table 3, 4)

Significant differences between the stores in respect to storage conditions were determined (Table 3) The most suitable storage conditions with average 16°C temperature and 78% mass humidity during the whole storage determined in the model store. While temperature differences and moisture migration between the zones in the model store was prevented through aeration, important temperature differences between the zones in the temporary stores were determined and moisture migration occurred. Especially upper parts of the mass in the temporary store were cooler than the bottom of the mass. This was because it was affected by the weather temperature changes more. When the stores were compared in terms of humidity, while there were not any differences between the zones in temporary stores, differences were determined in the model store. But, while average mass humidity in the model store was around the recommended value of 78% for sunflower seed storage (78%) it rose to 92% in the temporary store[4,7,9,12,19,20,22,23].

Sunflower quality criteria

Moisture content: Moisture content is one of the most important criteria effective on the losses during the storage. Therefore, moisture contents of sunflower samples taken regularly from the stores were determined and changes in the moisture contents with time during the storage were presented in Table 5.

As shown Table 5, while the moisture content in the temporary store increased during initial storage months, it did not change in the model store because of aeration.

Table 2: Recorded in temperature and humidity with time in the model store

Model store date	Temperature					Humidity				
	Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Out side	Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Out side
06/09/01	32.30	32.05	32.30	32.20	22.90	77.05	75.40	76.20	74.30	69.60
12/09/01	27.15	26.20	27.30	26.10	22.10	72.80	71.05	70.70	67.45	64.00
19/09/01	29.15	28.00	31.75	29.80	20.10	70.85	71.40	71.65	69.45	70.20
24/09/01	25.95	25.60	26.05	25.75	22.50	71.45	71.90	70.15	69.95	73.30
01/10/01	22.70	21.90	23.40	23.25	20.70	66.40	68.50	67.30	67.75	74.10
07/10/01	25.45	25.00	26.10	26.20	16.00	71.05	74.25	71.65	73.95	80.00
15/10/01	18.65	17.95	18.40	18.75	13.30	72.30	72.95	72.90	73.65	77.10
23/10/01	23.80	23.05	24.45	22.65	16.60	69.45	70.35	68.55	71.40	68.30
30/10/01	17.75	17.90	17.20	17.45	11.30	73.40	73.50	72.25	73.70	73.20
05/11/01	14.55	14.85	13.80	14.10	8.60	82.10	83.70	80.90	81.30	77.70
12/11/01	17.40	17.65	17.05	17.50	11.40	76.75	77.40	76.60	79.50	73.80
19/11/01	9.10	9.40	8.90	9.05	6.14	83.45	82.80	81.75	84.25	73.90
26/11/01	8.30	8.75	8.10	8.20	4.00	76.95	79.30	79.20	79.45	79.00
05/12/01	3.35	3.85	3.15	3.35	0.20	83.00	84.40	79.70	81.95	85.00
12/12/01	-0.65	-0.20	-0.05	-0.75	-2.70	82.55	81.50	79.05	82.20	80.80
25/12/01	2.35	2.95	2.00	2.00	-2.40	82.35	82.20	78.10	82.60	85.20
10/01/02	-0.45	-0.35	-0.80	-0.65	-0.40	80.85	80.45	79.85	79.30	81.00
20/01/02	3.20	2.95	3.40	3.15	1.50	83.90	84.00	81.95	83.75	82.80
03/02/02	11.95	11.60	12.20	11.75	3.90	80.90	79.70	79.05	82.25	83.40
19/02/02	12.10	11.90	12.80	12.45	4.60	81.70	82.75	79.25	80.80	77.80
02/03/02	14.20	13.15	15.70	15.40	6.80	83.05	82.35	84.30	85.20	79.80
08/03/02	17.35	16.20	18.40	18.10	10.10	76.95	76.70	78.25	80.50	62.50
15/03/02	15.25	14.25	15.95	14.15	8.70	76.45	77.80	79.90	79.45	79.90
24/03/02	9.95	9.75	10.90	10.50	9.50	85.35	86.50	82.45	83.80	84.40
30/03/02	13.20	12.45	13.60	12.80	5.80	76.90	79.55	74.05	74.90	80.16
08/04/02	14.50	13.65	15.45	15.00	7.80	73.75	78.35	68.65	72.75	71.40
15/04/02	17.00	15.75	17.95	16.90	10.60	79.90	79.00	83.30	80.45	84.00
25/04/02	13.20	12.10	13.85	13.10	11.10	82.05	82.30	80.60	82.05	62.20
03/05/02	22.30	21.50	24.00	24.20	14.00	77.65	74.70	86.70	85.95	75.20
09/05/02	17.70	17.15	17.40	17.25	15.20	74.20	70.90	74.15	76.35	71.50
17/05/02	26.00	23.95	27.30	27.90	16.50	80.40	79.95	83.10	83.50	56.50
24/05/02	16.40	15.65	18.45	18.05	17.70	68.85	69.80	72.55	76.80	66.80
05/06/02	24.10	22.90	25.25	23.95	19.70	77.60	78.00	76.25	80.25	69.40

Table 3: Duncan test results related to storage conditions in the stores

Store	Store	Average	Standard error	Duncan* 0.01
Temperature	Model	16.050	0.041	A
	Temporary	23.531	0.041	B
Mass humidity	Model	78.074	0.051	A
	Temporary	92.197	0.051	B

Moisture content increase in the temporary store was higher in the upper part of the mass when compared with the bottom and this increase resulted by the moisture migration because of temperature differences between zones and entering rain water into this store in the December and January. The outdoor temperature increase during spring, therefore the increase in the mass temperature, caused to a decline in the moisture content. But afterwards moisture content increased again both with the start of rainy period due to the leakage of small amount of air in to the store and with increasing the crop respiration. Although moisture content decreased minimally in windy and cloudless days, increasing outside temperature, crop respiration and insect's activity caused to increase the moisture content. In April, sunflower in the upper part of the mass in the temporary store germinated owning to increase in the moisture content and high temperature. In the model store, increase in the moisture content was prevented by means of aeration, but when the aeration stopped in the winter, it increased. Moisture content in the upper part of the mass rose rapidly during spring. This is due to the leakage of the rain into the store.

When the moisture content in the temporary store investigated during storage period, it is seen that the moisture content in this store exceeded 8% suggested level for safely storage by Hofman and Hellevang[9], Harrier[12], Brooker *et al.*[19], Hellevang[20], Patterson[22], Hellevang[23], Anonymous[24] and in the beginning from second month of the storage and it remained over 8% until end of the storage. On the other hand moisture content in the model store was below 8% continuously except for January.

Table 4: Duncan test results related to storage conditions in the stores

Store *Zone	Store	Zone	Avarage	Standard error	Duncan* 0.01
Temperature	Model	Middle 0.25	16.156	0.083	B
		Middle 0.75	15.587	0.083	A
		Side 0.25	16.233	0.083	B
		Side 0.75	16.225	0.083	B
	Temporary	Middle 0.25	23.173	0.083	D
		Middle 0.75	24.927	0.083	E
		Side 0.25	22.800	0.083	C
		Side 0.75	23.222	0.083	D
Mass Humidity	Model	Middle 0.25	77.977	0.103	B
		Middle 0.75	78.043	0.103	B
		Side 0.25	77.571	0.103	A
		Side 0.75	78.704	0.103	C
	Temporary	Middle 0.25	92.349	0.103	D
		Middle 0.75	92.164	0.103	D
		Side 0.25	92.305	0.103	D
		Side 0.75	91.969	0.103	D
Store*Period	Store	Period			
Temperature	Model	September	32.213	0.131	O
		October	26.140	0.131	M
		November	17.488	0.131	I
		December	4.603	0.131	C
		January	0.796	0.131	A
		February	9.115	0.131	D
		March	16.060	0.131	H
		April	13.200	0.131	G
		May	17.583	0.131	I
		June	23.307	0.131	L
	Temporary	September	35.625	0.131	P
		October	31.820	0.131	O
		November	20.362	0.131	K
		December	9.653	0.131	E
		January	2.298	0.131	B
		February	10.938	0.131	F
		March	18.188	0.131	J
		April	29.043	0.131	N
		May	35.793	0.131	P
		June	41.588	0.131	Q
Mass Humidity	Model	September	75.738	0.162	D
		October	70.483	0.162	A
		November	75.133	0.162	C
		December	81.303	0.162	HI
		January	80.710	0.162	H
		February	81.663	0.162	I
		March	80.910	0.162	H
		April	78.160	0.162	F
		May	79.390	0.162	G
		June	77.250	0.162	E
	Temporary	September	74.125	0.162	B
		October	79.843	0.162	G
		November	89.710	0.162	J
		December	96.828	0.162	LM
		January	98.285	0.162	O
		February	96.905	0.162	LM
		March	94.473	0.162	K
		April	97.637	0.162	N
		May	97.415	0.162	MN
		June	96.747	0.162	L

According to Duncan test (Table 6), moisture content change in the temporary store was 3.5 times larger than in the model store and increased by 2.64%. This was because of being influenced much by the outside air condition and rain water entered into the store[10,23].

Generally, in the model store, moisture content change in the upper part of the mass was less when compared with the lower part of the mass. On the other hand, moisture content change in the upper part of temporary store was higher than in the lower part of the mass. This is because the upper parts and sides of in the temporary store quickly affected by changing weather temperature and the moisture migration that is resulted from temperature differences in the store as expressed by Hofman and Hellevang[9], Harner *et al.*[10], Hellevang[23].

Table 5: Recorded in moisture content of sunflower samples (dry bases)

Moisture content% date	Temporary Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Model Middle 0.25	Middle 0.75	Side 0.25	Side 0.75
06/09/01	5.60	5.46	6.30	6.32	6.80	7.10	7.06	6.90
07/10/01	6.88	6.11	6.93	6.40	6.64	7.00	6.85	7.12
12/11/01	7.74	7.00	9.20	7.93	6.70	6.70	6.60	7.20
12/12/01	9.95	7.52	12.80	8.25	7.69	7.65	8.66	8.00
10/01/02	10.99	8.92	13.50	8.95	8.44	7.93	8.98	8.86
10/02/02	11.60	8.28	11.00	7.67	7.96	8.34	8.97	10.30
08/03/02	8.60	7.05	8.65	7.80	6.75	7.55	7.95	8.50
08/04/02	10.21	7.62	13.38	8.98	7.55	8.09	8.10	9.04
10/05/02	7.96	6.29	10.36	6.71	6.97	7.93	7.67	8.69
06/06/02	9.60	7.90	12.20	8.20	5.84	7.55	7.11	8.54

Table 6: Duncan test results of moisture contents in the stores

Store	Store		Avarage	Standard error	Duncan* 0.01
Moisture Content	Model		0.742	0.004	A
	Temporary		2.648	0.004	B
Store *Zone	Store	Zone			
Moisture Content	Model	Middle 0.25	0.334	0.007	A
		Middle 0.75	0.484	0.007	B
		Side 0.25	0.735	0.007	C
		Side 0.75	1.415	0.007	D
	Temporary	Middle 0.25	3.313	0.007	F
		Middle 0.75	1.755	0.007	E
		Side 0.25	4.132	0.007	G
		Side 0.75	1.391	0.007	D
Store*Period	Store	Period			
Moisture Content	Model	September	0.000	0.011	C
		October	-0.062	0.011	B
		November	-0.165	0.011	A
		December	1.035	0.011	H
		January	1.588	0.011	J
		February	1.928	0.011	K
		March	0.723	0.011	F
		April	1.230	0.011	I
		May	0.850	0.011	G
		June	0.295	0.011	D
	Temporary	September	0.000	0.011	C
		October	0.660	0.011	E
		November	2.048	0.011	L
		December	3.710	0.011	O
		January	4.670	0.011	Q
		February	3.713	0.011	O
		March	2.100	0.011	M
		April	4.123	0.011	P
		May	1.905	0.011	K
		June	3.550	0.011	N

Table 7: Recorded in oil content of sunflower samples

Oil content% date	Temporary Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Model Middle 0.25	Middle 0.75	Side 0.25	Side 0.75
06/09/01	43.45	43.70	42.30	43.20	40.85	41.00	40.60	40.80
07/10/01	43.25	43.15	41.80	42.95	40.55	40.75	40.30	40.50
12/11/01	43.00	42.80	41.60	42.10	40.10	40.60	40.15	40.30
12/12/01	42.60	42.60	40.90	41.65	40.00	40.50	40.00	40.20
10/01/02	42.10	42.00	40.65	41.15	39.85	40.30	39.80	40.00
10/02/02	41.15	41.35	39.35	40.50	39.45	39.95	39.40	39.70
08/03/02	39.70	40.90	39.10	40.10	39.10	39.60	39.00	39.30
08/04/02	39.50	40.40	38.70	39.80	38.95	39.10	38.60	39.00
10/05/02	37.25	39.00	37.35	38.80	38.65	38.90	37.95	38.80
06/06/02	36.25	37.60	35.40	36.90	38.05	38.30	37.25	38.15

Table 8: Duncan test results relating to oil contents in the stores

Store	Store		Avarage	Standard error	Duncan* 0.01
Oil Content	Model		-1.199	0.004	A
	Temporary		-2.504	0.004	B
Store *Zone	Store	Zone			
Oil Content	Model	Middle 0.25	-1.295	0.007	C
		Middle 0.75	-1.080	0.007	A
		Side 0.25	-1.295	0.007	C
		Side 0.75	-1.125	0.007	B
	Temporary	Middle 0.25	-2.625	0.007	G
		Middle 0.75	-2.320	0.007	D
		Side 0.25	-2.585	0.007	F
		Side 0.75	-2.485	0.007	E
Store*Period	Store	Period			
Oil Content	Model	September	0.000	0.011	A
		October	-0.287	0.011	B
		November	-0.525	0.011	D
		December	-0.637	0.011	E
		January	-0.825	0.011	F
		February	-1.187	0.011	G
		March	-1.550	0.011	H
		April	-1.887	0.011	J
		May	-2.225	0.011	K
		June	-2.863	0.011	M
	Temporary	September	0.000	0.011	A
		October	-0.375	0.011	C
		November	-0.787	0.011	F
		December	-1.225	0.011	G
		January	-1.688	0.011	I
		February	-2.575	0.011	L
		March	-3.212	0.011	N
		April	-3.537	0.011	O
		May	-5.037	0.011	P
		June	-6.600	0.011	A

Oil content: Changes in oil contents, which is the most important feature of sunflowers, was determined by analyzes that was regularly done on the samples taken from stores and changes in the oil contents with time were presented in Table 7.

As shown in Table 7, oil contents in the temporary store were continuously decreased during the storage. The oil content of 43% at the beginning decreased approximately 0.3-0.5% per month until January. This loss in this period was higher in the side of store and lower part of the store. This is because of high temperature and moisture content of the crops in these zones. In January and February, decreasing oil content rose in the upper part of the store. Result of moisture migration caused temperature differences in this store and precipitations, moisture content increased and this accelerated the spoilage of oil. Oil content in the temporary store decreased to 40.5% in February, 39.6% in April and 36.5% in June. Oil loss in temporary store was approximately 5% during the last 5 month of storage.

Oil contents in the model store were continuously decreased during the storage, but relatively less losses occurred in this store when compared with the temporary store due to keeping low temperature and humidity by means of aeration and moisture content which was lower than 8%, suggested for a safe storage[4,5,12,19,20].

Decreasing moisture content in the model store continued to same level in the different zones until February. It increased slightly in February and March and decreased 0.3-0.5% per month. In this period, temperature increase in the crop mass with increasing weather temperature relative humidity, increasing the mass humidity and moisture content of crop because of not operating aeration caused to increase in the oil losses. In the last months, oil losses increased minimally because of the rose in the moisture content and free fatty acidity of crop with rising mass temperature and humidity in spite of aeration[17].

According to statistical evaluation (Table 8), while model store gave 1.2% decrease in the oil content, temporary store gave 2.5%. Oil loss in the model store was two times less than the temporary store. In this result was shown that oil losses during storage could be reduced in half by only aeration. When the zones in the stores were compared, oil losses in the upper parts of the stores were more than in the other zones, but oil losses in the temporary store were more than in the model store.

Oil contents in both stores decreased during the storage and it decreased to the lowest value at the end of the storage. At the end of the nine months, while model store gave the best result with 2.863% decrease in oil content and the worst result was obtained in the

Table 9: Recorded in free fatty acidity of sunflower samples

Free faty acidity date	Temporary Middle 0.25	Middle 0.75	Side 0.25	Side 0.75	Model Middle 0.25	Middle 0.75	Side 0.25	Side 0.75
06/09/01	0.43	0.29	0.38	0.29	0.38	0.30	0.25	0.35
07/10/01	0.47	0.37	0.44	0.39	0.41	0.37	0.31	0.42
12/11/01	0.55	0.41	0.56	0.45	0.48	0.40	0.47	0.45
12/12/01	0.68	0.55	0.62	0.55	0.55	0.42	0.48	0.61
10/01/02	0.71	0.86	0.82	0.76	0.62	0.43	0.50	0.68
10/02/02	0.97	1.10	1.02	1.20	0.82	0.48	0.80	0.79
08/03/02	1.90	2.20	2.10	2.14	0.96	0.81	0.95	0.85
08/04/02	3.10	4.10	3.20	4.90	0.98	0.81	1.18	1.10
10/05/02	5.30	5.55	8.90	5.70	1.30	1.14	1.39	1.25
06/06/02	6.90	6.20	10.90	6.70	1.45	1.30	1.62	1.40

temporary store with 6.6% decrease. According to these results, temporary stores must not used for long time because of high losses as determined by Hellevang[4], Hall[6], Hofman and Hellevang[9], Hellevang[20], Patterson[22], Hellevang[23], Jones and Shelton[25], Hellevang[26].

Free fatty acidity: Free fatty acidity which affects losses occurred during the refinement was determined by analysis that was regularly done on the sample taken from the stores and changes in the free fatty acidity with time were presented in Table 9.

Free fatty acidity of sunflowers in both of the stores continuously increased during the storage. Free fatty acidity in the temporary stores did not exceed 1.2-1.5% suggested for suitable free fatty acidity by Gumuskesen[27] until February. But beginning from February, acidity in this store quickly increased and it rose 7.683% in June. In this period, high temperature and moisture content in the store caused to increase in the free fatty acidity. Free fatty acidity in the temporary store increased more in the side of the store and in upper part of the mass. Increased moisture content owning to moisture migration and quickly affected from weather condition of side and upper part of the mass caused to increase the acidity.

As seen in Table 9, free fatty acidity in the model store increased 0.05 to 0.06% per month during the first five months of storage and after then the monthly increase in the free fatty acidity was recorded as 0.2% because of the increase in the mass temperature and moisture content in this period. Decreases in the mass temperature and moisture content with aeration limited the increase the acidity in this period in some extends. At the end of the storage, free fatty acidity in model store did not exceeded 1.5%.

Duncan tests to determine the differences between the stores were given in Table 10. Among the stores, average acidity varied 0.437% in the model store and 2.023% in the temporary store.

End of the storage, while increase acidity was 1.125% for the model store, it was 7.332% for temporary store. The increase in free fatty acidity in the temporary store was six times more than the model store. Especially acidity in the temporary store quickly increased in last three months of storage. This case was result of increasing the mass temperature and humidity because of warming up the outside temperature and relative humidity in this period and increasing the moisture content owning to rain entering into the store during rainy periods.

In this study conducted in the Thrace Region, influences of the storage conditions of temporary stores widespreadly used for storing sunflower on the quality losses occurred during storage was investigation. For this aim, in the selected temporary store and a model store built specifically for this research, mass temperature and humidity as storage conditions and moisture content, oil content and free fatty acidity as sunflower quality criteria were determined and evaluated during the storage.

In the temporary store, mass temperature decreased and mass humidity increased during autumn when the outside temperature decreased, because the store was quickly affected by the outside conditions. In this period, while the side of the store on the blow direction of wind it got quickly cold, the other side and the middle of the store got colder by time. Therefore, significant temperature differences in the store occurred and moisture migration arised. In this period which mass was generally cold and the mass temperature of 35°C at the beginning decreased to 2.29°C in January and mass humidity of 74% increased 98% in January. Mass temperature was recorded within the suggested suitable storage conditions when the critical limit was assume to be 17°C as reported by Cloud and Morey[7], Thompson and Shelton[13], Hellevang[20], Jones and Shelton [25], Hellevang [26]after November. From the early January, mass temperature increased until end of storage and it exceeded suitable storage temperature after March. In the same period, although mass humidity decreased slightly with increasing the temperature sometimes, generally it remained at the level of 97% because of crop respiration and raining.

Table 10: Duncan test results relating to the free fatty acidities for the stores

Store	Store		Avarage	Standard error	Duncan* 0.01
Free Fatty Acidity	Model		0.437	0.003	A
	Temporary		2.023	0.003	B
Store *Zone	Store	Zone			
Free Fatty Acidity	Model	Middle 0.25	0.415	0.006	B
		Middle 0.75	0.349	0.006	A
		Side 0.25	0.545	0.006	D
		Side 0.75	0.440	0.006	C
	Temporary	Middle 0.25	1.689	0.006	E
		Middle 0.75	1.873	0.006	F
		Side 0.25	2.514	0.006	H
		Side 0.75	2.018	0.006	G
Store*Period	Store	Period			
Free Fatty Acidity	Model	September	0	0.009	A
		October	0.0575	0.009	B
		November	0.130	0.009	C
		December	0.195	0.009	D
		January	0.238	0.009	E
		February	0.403	0.009	F
		March	0.573	0.009	H
		April	0.700	0.009	I
		May	0.953	0.009	J
		June	1.125	0.009	K
	Temporary	September	0	0.009	A
		October	0.075	0.009	B
		November	0.150	0.009	C
		December	0.258	0.009	E
		January	0.445	0.009	G
		February	0.730	0.009	I
		March	1.742	0.009	L
		April	3.482	0.009	M
		May	6.020	0.009	N
		June	7.332	0.009	O

The criteria for sunflower in the temporary store were negatively affected by affecting from weather condition more and rain water entrance into the store. Moisture content of the crop in this store exceeded 8% which was recommended level for a safe storage by Hofman and Hellevang[9], Harrier [12], Brooker *et al.*[19], Hellevang[20], Patterson[22], Hellevang[23] and Anonymous[24] and the highest moisture content occurred in January and April. This was because of warming weather conditions and rain. The result of negative storage conditions in the store, oil content and free fatty acidity of crop were negatively affected. While oil content and free faty acidity of crop did not change significantly during the autumn, in the spring, oil content quickly decreased unlike acidity. At the end of the storage, oil content of the crop decreased 6.60%, acidity of crop increased 7.33%.

Temporary storage widespreadly used in the Thrace region caused losses insignificant amount. The raw oil losses of crops stored in the temporary stores in the Thrace region are around 19 500 tone per year and this corresponds 24 billion TL according to the price of 2002. Therefore temporary stores should not be used for sunflower storage, but if used, the durations should be less than five months in the autumn when the weather temperature decreases continuously. This kind of stores should not be also used in the districts having much rain.

Mass temperature of 32°C in the model store at the beginning decreased below 17°C that is recommended for safely storage when the aeration began from end of October and remained below this level until June[7,13,20,25,26]. Mass humidity in this store increased 81% from December to March because of not operating the aeration in this period, but it again decreased with aeration. Moisture content of crop during the storage period except for February kept under 8% suggested for safely storage by Hofman and Hellevang[9], Harrier [12], Brooker *et al.* [19], Hellevang[20] and Patterson[22]. Supplying suitable storage conditions and recommended moisture content in this store lowered the losses. At the end of the storage, oil losses occurred 2.8% and free fatty acidity increased 1.44%. Losses in the model store materialized quite low level comparing with temporary store and losses reduced approximately 70%. Therefore using this store for sunflower storage will supply important economical benefit.

REFERENCES

1. Arioglu, H., 1999. Cultivation of Oil Seed and Improvement. Cukurova Ünv. Agril. Fac. Pub., Adana, 220: 190.

2. Anonymous, 2002. Agricultural Structure (Production, Price, Value) 2000. Republic of Turkey, Government Statistical Enstitute. Publication Number 2547, Ankara.
3. Gaytancioglu, O., 1999. Farming Policies on Sunflower and Economical Analiysis of Storage Losses. T.U. Tekirdag Agricl. Fac., Tekirdag.
4. Hellevang, K.J., 1990. Crop Storage Management. NDSU. Extension Service, ND 58105-AE-791, North Dakota, USA.
5. Proctor, D.L., 1994. Grain Storage Techniques Evolution and Trends in Developing Countries. FAO Agricultural Service Bull. No. 109, ISBN 92-5-103456-7, Roma.
6. Hall, C.W. 1980. Drying and Storage of Agricultural Crops. The AVI Publishing Company Inc. ISBN 0-87055-364-X, USA.
7. Cloud, H.A. and R.V. Morey, 1991. Management of Stored Grain with Aeration, University of Minnesota. Collage of Agril. Food Environ. Sci., FO 1327-GO, USA.
8. Bloome, P., G. Brusewitz and S. Harp, 1995. Aeration and Cooling of Stored Grain. Oklahoma State Unv. Cooperative Extension Service, Division of Agril. Sci. and Natural Resource, F-1101, Oklahoma.
9. Hofman, V.L. and K.J. Hellewang, 1997. Harvesting Drying and Storage of Sunflower. Sunflower Technology and Production, American Society of Agronomy, Soil Science Society of American, Agronomy Monograph No. 35, Madison, USA.
10. Harner, J.P., T.J. Herrman and C. Reed, 1998. Temporary Grain Storage Considerations. Kansas State Unv. Agricultural Experiment Station and Cooperative Extension Service, MF 2362, Kansas.
11. Soysal, M.I., 2000. Principal of Biometry. T.U. Tekirdag Agricultural Fac. Publication No. 74, Tekirdag.
12. Harrier, J.P., 1987. Drying and Storing Sunflowers. Kansas State Unv. Cooperative Extension Service, Ag. Facts 158, Kansas.
13. Thompson, T.L. and D.P. Shelton, 1993. Aeration of Stored Grain. Nort Dakota State Unv. Extension Service, G84-692, USA.
14. Noyes R.T., B.L. Clary, G.W. Cuperus, 1998. Maintaining Quality of Stored Grain by Aeration. Oklahoma State Unv. Extension Service Division of Agricultural Science and Natural Resources, USA.
15. Harner J.P. and K. Hellevang, 1999. High Plains Sunflower Production Handbook. Kansas State Unv. Agricultural Experiment Station and Extension Service, MF 2384.
16. Ekmeklier, H.Y. and H.H. Gecit, 1986. Standardized and Stored of Fild Crops. Ankara Ünv. Agril. Fac. Publication No: 989, Ankara.
17. Nas, S., H.Y. Gokalp and M. Unsal, 1998. Technology of Vegetal Oil. Pamukkale Ünv. Eng. Fac. Publication No 005, 329s, Denizli.
18. Anonymous, 1987. International Union for Pur16°C temperature and 78% mass humidity e and Applied Chemistry, Standard Methods of Analysis for the Analysis of Oil. Fats and Derivatives, 7th. End., Blacwell, Jevent Publishers, Oxford.
19. Brooker, D.B., F.B. Arkema and C.W. Hall, 1992. Drying and Storage of Grains and Oilseeds. An AVI Book, Published by Van Nostrand Reinhold, ISBN 0-442-20515-5, New York.
20. Hellevang, K., 2000. Storing Wet Sunflower. Irrigator's Workshops, Bismarck Radisson Inn. 4 Decenber 2000.
21. Navarro, S., 1996. Aeration and Cooling for Control of Stored Grain Insect. International Course on Agricultural Engineering Technology of Grain Storage, The Volkani Center, Israel.
22. Patterson, H.B.W. 1989. Handiling and Storage of Oilseed, Oils, Fats and Meal. Elsevier Applied Science, NewYork, pp: 294.
23. Hellevang, K., 1998. Temporary Storage of Sunflower Seed. The Sunflower Magazine, Septenber, National Sunflower Association.
24. Anonymous, 1995. Drying and Storage Sunflower Production. NDSU Extension Service, Agricultural Experiment Station, EB 25, USA.
25. Jones D., P. Shelton, 1994. Management to Maintain Stored Grain Quality. Nebraska State Unv. Cooperative Extension Service, Institute of Agriculture and Natural Researces, G 94-1199-A, USA.
26. Hellevang, K.J., 1995. Grain Moisture Content Effects and Management. NDSU. Extension Service AE-905, North Dakota.
27. Gumuskesen, A.S., 1999. Technology of Vegetal Oil. Asya Tip Publishing Company. ISBN 975-941208-0-5, Izmir, Turkey, pp: 1-15.