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ACCELERATED DRYING OF SUN FLOWER SEEDS

Matouk, A. M. [1]; M. M. El - Kholy [2] and Solaf Abd El - Raheam [3]
[1] Agric. Eng. Dept, Fac. of Agric., Mansoura Univ
[2] Agric. Eng. Res. Institute, Dokki, Giza
[3] Agric. Eng. Res. Institute, Dokki, Giza

ABSTRACT

A study was carried out to test and evaluate the effect of accelerated drying of sunflower seeds on seeds moisture content, fungal load on seeds surface and stabilization of the extracted oil using a conduction heating rotary dryer. The drying temperatures were set at approximately 75, 85, 95,105, 115, 125, 135 and 145^{o} C and the drying times were set at 3, 6, 9, 12 and 15 min. The results showed that all the drying process occurred at the falling rate period in which the rate of evaporation tends to fall as the moisture content decreases and the drying curve decays exponentially towards the final moisture content. Rapid moisture removal from seeds was obvious in all experiments particularly at higher heating surface temperature and longer exposure time. The results also showed that the simple equation was satisfactorily described the drying behavior of sunflower seeds and predicted the change in seeds moisture content as indicated by the higher coefficient of determination (R^2). Meanwhile, high temperature conduction heating reduced the fungal load in sunflower seeds in an effective manner. Also, the extracted sunflower oil was stabilized at certain combinations of heating surface temperature and exposure time as indicated from the lower values of free fatty acids of the these samples. It can be said that, the accelerated drying and heat stabilization of sunflower seeds using the conduction heating rotary dryer may be considered as an effective procedure for moisture reduction, fungal inactivation and oil stabilization. In general, heating surface temperature of 145^{o} C and the exposure time of 15 min are recommended to decrease the moisture content of sunflower seeds to the safe level of 5.8% (w.b), the fungal load to 102 colonies/g. and the percentages of free fatty acids to1.97 %.

INTRODUCTION

In Egypt the total productivity of cooking oil represent 15-20% of the total oil requirement while 80-85% is imported from different countries. In the last decade, many efforts were followed in an attempt to narrow the nutritional gap by decreasing the average consumption of oil per person every year while increasing oil quality (Owies, 2003). Sunflower is one of the main oilseeds worldwide being produced for example, in countries such as Argentina, United States of America, Russia, France, China and Spain. It was considered as an ornamental flower until 19th century, after that it was cultivated as an oil seed plant for extraction of oil.

Sunflower ranks as the second after soybeans with respect to oil production in the world. In Egypt, sunflower is considered a promising crop to face the shortage of vegetable oils because of its adaptability to grow in various soils and climatic conditions (Keshta *et al.*, 1992). The planted area of sunflower oil producing varieties is only 10385 feddan with total production of 10178 tones (Agric Stat.,2005). This area is too small to cover and meet the needs of Egyptian consumers to vegetable oil specially with the decreasing of cotton planted area. So the Egyptian Agricultural strategies till 2017 plans to increase the area cultivated by the oil crops specially (canola and sunflower) by 200,000 feddan to produce about 100,000 tones oils. This help in reducing the shortage of vegetable oil (Egyptian Agricultural strategies, 2007).

Traditional method of drying is done on open ground. The disadvantages associated with this method are that the process is slow and that insects and dust get mixed with the product. The use of dryers helps to eliminate these disadvantages. Drying can then be done faster and in a controlled fashion. In addition, a better-quality product is obtained (Abd El-Moteleb *et al.*, 2009).

For this reason, the most proper method for drying this type of seeds with killing microorganisms is based on the application of fluidized bed heating or direct conduction heating. These techniques not only kill the microorganisms but also inactivate enzymes causing deterioration of seeds oil during temporary or long storage periods. (Dermott and Evans 1980; Hendawy, 2003).

El-Sahrigi *et al.* (1999) studied the effectiveness of high temperature short time conduction heating for accelerated drying and sterilization of high moisture rough rice. They found that, the moisture removal rate depends upon heating surface temperature, exposure time and grain feed rate. Also, they mentioned that, the high temperature short time conduction heating distinctly reduced fungal activity in rough rice.

Hendawy (2003) carried out a study to evaluate the use of high temperature short time conduction heating for rice bran stabilization and the effect of type of storage sacks on safe storage period of the stabilized bran. The results showed that, rice bran moisture content decreased with the increase of heating surface temperature and the exposure time. Quality evaluation tests showed a reduction in fungal growth rate and percentage of free fatty acids (FFA) with the increase of heating surface temperature and exposure time and also for the treatments stored in poly-ethylene sacks in comparison with burlap sacks.

El-Kholy and Tharwat (2008) reported that, the accelerated drying and heat stabilization of canola seeds using the conduction heating rotary dryer may be considered as an effective procedure for moisture reduction, fungal inactivation and oil stabilization.

The present study aims to test and evaluate the effect of high temperature short time conduction heating of the sunflower seeds on seed drying, oil stabilization, and fungal inactivation.

MATERIALS AND METHODS

The conduction heating unit:

An experimental scale rotary conduction heating unit developed by El-Kholy (1998) was used for the experimental work. The unit consists of a rotary cylinder (0.6 m diameter and 0.2 m long) made of 1mm galvanized iron sheet enclosed by a fixed insulated cylinder (0.8 m diameter and 0.3 m long). One side of the rotary cylinder connected to a driving mechanism consists of

0.15 m diameter steel flange fixed to the side cover of the rotary cylinder and welded to a steel bar riding with a heavy duty ball bearing. A 0.5 kW low speed motor with different sizes of pullies used for power supply and speed control of the rotary cylinder. The other side of the rotary cylinder serves as an inlet for sunflower seeds samples through a 0.1m diameter center hole. The heat treated sunflower seeds discharged through a perforated removable sector of the cylinder bottom as shown in Fig. (1). For heating and temperature control of the rotary cylinder surface, two kW electric resistance heaters were placed at the inner surface of the fixed insulated cylinder (between the rotary cylinder and the insulated exterior cylinder) to heat the surface of the rotary cylinder. The surface temperature of the rotary cylinder could be raised up to 175^{o}C and maintained within ± 1 ^{o}C using a precise digital thermostat controlled by an electric contactor.

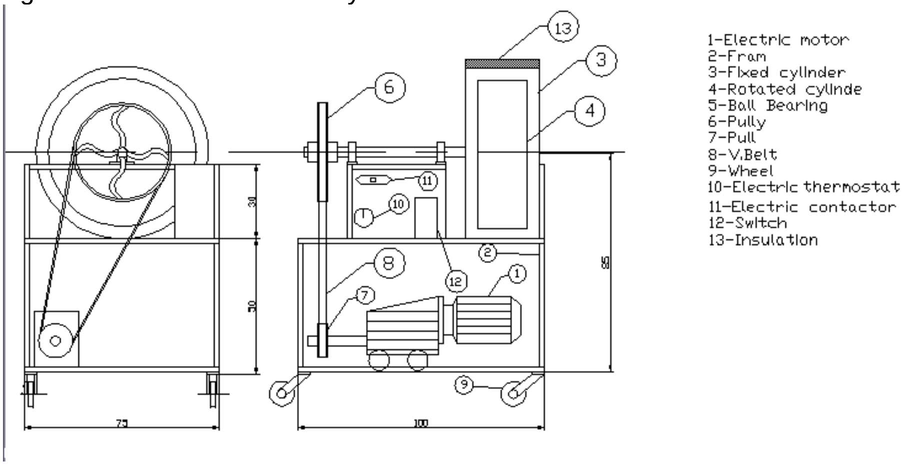

Fig. (1): Schematic diagram for the conduction heating unit

Test procedure and measurements:

The accelerated drying unit was used to dry sunflower seeds at high levels of cylinder surface temperatures. Sunflower seeds at an initial moisture content of 29.2 % (wb.) were used for the drying and heat stabilization processes using the conduction heating rotary unit. The harvested seeds were sieved to separate the foreign matter and the un-filled seeds and then it was stored in deep freezer adjusted at (–5^{o} C) to suppress fungal growth and minimize quality changes. High temperature short time drying technique (HTST) was applied under eight levels of heating surface temperatures (75, 85, 95, 105, 115, 125, 135 and 145^{o} C) and five levels of exposure time (3, 6, 9, 12 and 15 min). Before each experimental run, seeds samples were taken out from the freezer and left until the initial temperature of seeds approached a level equal to that of room temperature. The samples were kept at insulated container in order to maintain the uniformity of the initial seeds temperature during the experimental work. Prior to each experiment, a dummy sample was used and the temperature of the cylinder surface was adjusted to the required level, then as the surface temperature of the rotary cylinder became stable the dummy sample discharged and replaced by the testing sample.

Drying runs were started after attaining the required heating surface temperature of the drying unit. After heating the seeds (0.75 kg/run) to the required heating time, they were cooled to room temperature in wooden box covered with a perforated aluminum foil to allow gradual escape of vapor during the cooling process. After cooling process, the heat treated seeds were taken out from the rotary heating unit, and then divided into three sub samples, 250 g each, the first one used for fungal colony count, the second was used to determine the seeds final moisture content, while the third one was used for oil extraction and determination of Free Fatty Acid (FFA %) and Peroxide value. The following measurements were preceded during the experimental work:

Moisture content of sunflower seeds:

The standard of ASAE. (2003) for sunflower seeds moisture measurement was used for determining the seeds moisture content after each drying run. Ten grams of sunflower seeds were placed at 130^o C for 3 h, and then it was kept in a desiccator at room temperature. The dried samples were weighed again using an electronic digital balance and the moisture content of sunflower seeds was calculated on wet basis.

Surface temperature of the rotary cylinder:

The remote–type infra red spot thermometer model (HT-11) was used to measure the rotary cylinder surface temperature of the stabilization heating unit during the rotation process. The emissive of the thermometer was adjusted at 0.85 for iron sheet surfaces and the temperature was measured at different points. The heating surface temperature was considered as the average of the obtained readings.

Bulk temperature of the heat-treated sunflower seeds:

The bulk temperature of sunflower seeds was immediately measured at the end of each experimental run. The discharged seeds were received in an insulated glass cylinder and the sensing prop of a one point temperature meter model (A.W. SPERRY DM-8600, Taiwan) with range of 0 to 400^o C was inserted through the seed bulk until reaching a constant reading.

Fungal count in sunflower seeds:

The spread plate method recommended by Flannigan (1977) was used to determine the change in fungal colony count in sunflower samples. Potato dextrose agar (PDA) at 3.9% concentration was used as a culture medium. Plates were incubated at 37º C for 4 days and the counts of fungi were determined as colonies/g.

Acid value (A.V.) of sun flower oil:

Acid value was determined according to the method descried by A.O.A.C. (1991). A known weight of the melted sample (ca 2.5 g) was dissolved in 25 ml of petroleum ether alcohol mixture (1:1, v/v). The contents of the flask were heated on a steam bath for 2 min. then titrated with alcoholic potassium hydroxide (0.1 n) in the presence of phenolphthalein as an indicator. The acid value was calculated according to the following equation:

$$\text{Acid value} = \frac{V.\,N.56.1}{W} \qquad \text{..................(1)}$$

Where:
V : Volume of alkali required to naturalize the free fatty acids.
N : Normality of KoH.
W : Weight of sample.

Peroxide value (P.V) of sunflower oil:

Peroxide value was measured according to the method descried by A.O.A.C. (1991). Five grams of melted lipid samples were dissolved by 50 ml of acetic acid chloroform mixture (2:1, v/v). One ml of saturated potassium iodide solution was added, then the mixture allowed to stand with occasional shaking for exactly I min and 30 ml of distilled water were added. The contents of flask were titrated with 0.1 N sodium thiosulphated solution until the yellow color had almost disappeared. Starch solution indicator (0.5 ml) was added and titration was continued until the blue color had just disappeared. The following equation was used to calculate the peroxide value of lipid samples under study.

$$Peroxide\ value = \frac{S.N.1000}{W} \ldots\ldots\ldots\ldots(2)$$

Where:
S : Titration of sample, ml;
N : Normality of sodium thiosulphate, dimensionless and
W : Weight of lipid sample, g.

Free fatty acids (FFA%) of sun flower oil:

Oil samples were extracted from sunflower seeds by soaking the crushed samples at n-hexane solvent for 24-48 hrs under room temperature. The solvent was completely re-gained by evaporation using a heated water bath at 85^{o} C and condensing it using a condensation unit. The remained oil samples were filled in glass bottles and used for the required measuring tests. The FFA % of oil samples were calculated as oleic acid using the corresponding acid value of each sample according to the A.O.A.C. (1991) as follows:

$$FFA\ \% = \frac{282\ \chi\ 100\ \chi\ \text{Acid Value}}{56.1\chi 1000} \ldots\ldots\ldots\ldots\ldots(3)$$

$$FFA\ \% = \frac{A.V}{1.99} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where:
A.V : Acid value

The values 282 and 56.1 refer to the equivalent weight of oleic acid and the potassium hydroxide (KOH) respectively. It should be mentioned that, to get true results of the free fatty acids, the laboratory tests were conducted after 15 days of samples storage under room condition.

Theoretical analysis of the drying process:

The simple drying equation were examined for describing the drying behavior and predicting the change in sunflower seeds moisture content under the studied accelerated drying technique. The simple drying equation written as follow:

$$MR = \frac{M - M_e}{M_o - M_e} = \exp(-k_s t) \quad \text{.....................................(5)}$$

Where:

MR : Moisture ratio, dimensionless

M : Instantaneous seeds moisture content at time t, (%, w.b)

Me : Equilibrium moisture content. (%, w.b)

Mo : Initial moisture content, % (w.b.).

t : Time, min

K_s : Drying constant, min $^{-1}$

There is no information available about the equilibrium moisture content of sunflower seeds in a temperature range of 75 to 145^o C when the air relative humidity is very low. However the sun flower seeds will be bone dried after prolonged heating under such condition. So the moisture ratio was approximated simply by dropping the equilibrium moisture content term and thus the ratio of instantaneous seeds moisture content of sun flower seeds to its initial moisture content was used for representing seeds moisture ratio.

The drying constant (K_s) of the simple exponential model was obtained by applying linear regression analysis to the value ln (M/Mo) and the drying time (t). The slope of the best fit straight line represents the value of the drying constant (K_s).

RESULTS AND DISCUSSION

Seeds bulk temperature:

Figure (2) presents the change in seeds bulk temperature as related to the exposure time at different levels of heating surface temperature. The results showed that, the seeds bulk temperature increased with the increase of exposure time and approached levels close to that of the heating surface temperature. The recorded seeds bulk temperature at the exposure times of 3 and 15 min were (53.6 - 72.8^o C), (62.1 - 81.5^o C), (71.5 - 87.7^o C), (73.9 - 93.5^o C), (81.1- 99.3^o C), (84.3 - 110.2^o C), (88.8 - 113.9^o C) and (93.8 - 131.2^o C) for the heating surface temperatures of 75, 85, 95, 105, 115, 125, 135 and 145^o C, respectively. The above mentioned results revealed that, longer exposure time gave a chance for sunflower seeds to gain heat until approaching a level close to that of heating surface temperature.

The dependence of bulk temperature on heating surface temperature and exposure time was described using multiple regression analysis. The empirical equation relating the change in sunflower seeds bulk temperature with the heating cylinder surface temperature and exposure times was as follows:

T_b = -7.738 + 0.494 (T) + 4.045(t) ………………………..(6)

Where:

T_b : Seeds bulk temperature, (^{o}C)

T : Heating surface temperature, (^{o}C)

t : Exposure time, (min.)

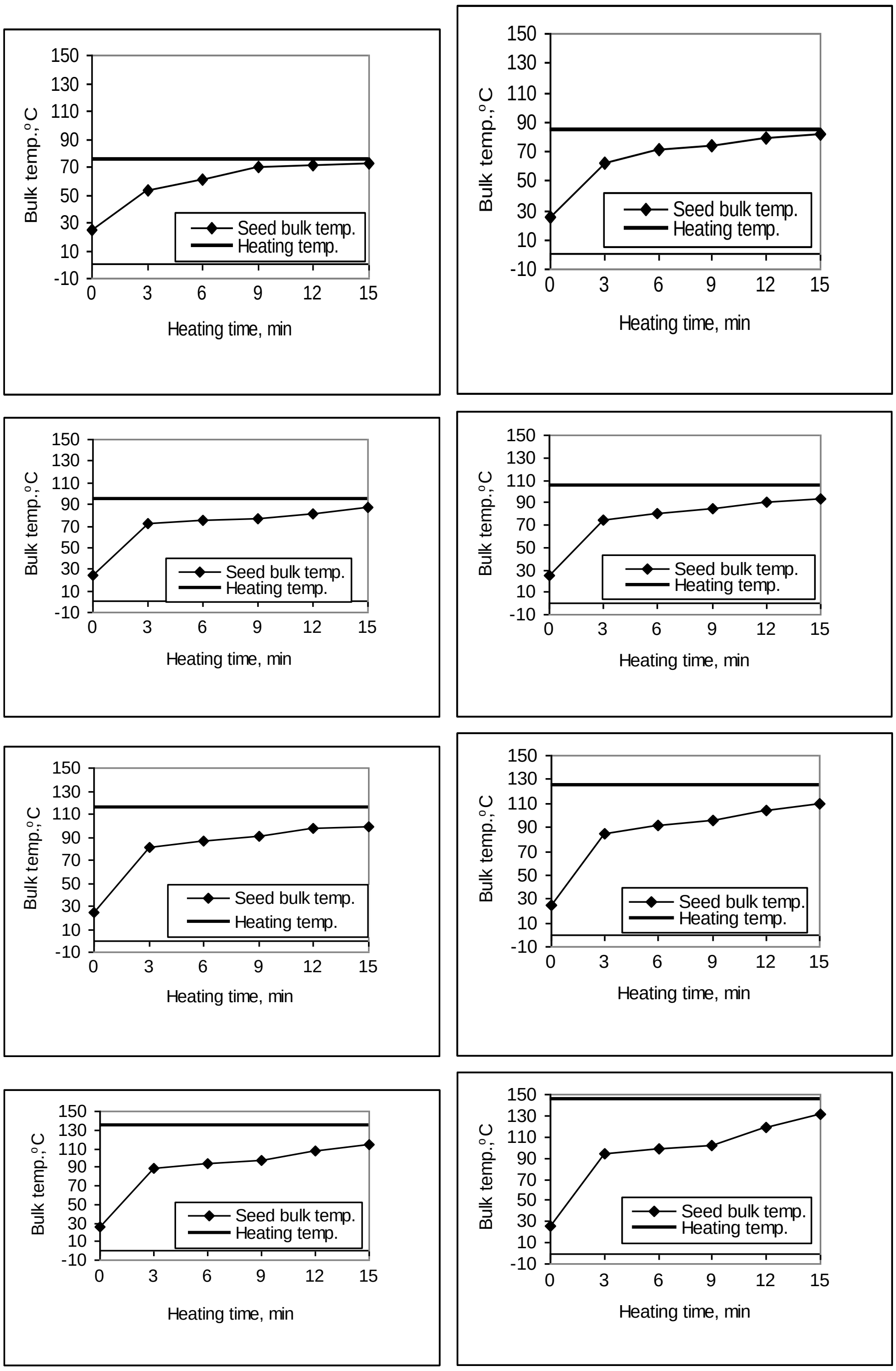

Fig. (2): Changes in sunflower seeds bulk temperature as related to exposure time at diferent cylinder surface temperature

Seeds moisture content:

The results presented in Fig. (3) show that all the drying process occurred at the falling rate period in which the rate of evaporation tends to fall as the moisture content decreases and the drying curve decays exponentially towards the equilibrium moisture content. Rapid moisture removal from seeds was obvious in all experiments particularly at higher heating surface temperature and longer exposure duration.

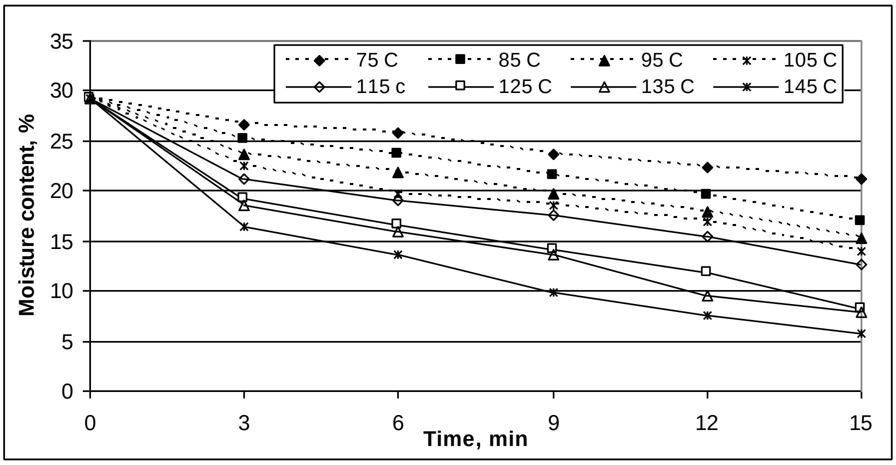

Fig. (3): A typical plot of the moisture content against the drying time at different cylinder surface temperatures.

Drying constants (K_s)

Table (1) presents the drying constants of the simple equation at different levels of cylinder surface temperature and exposure time.

Table (1): The average calculated values of the drying constants for the different drying tests.

Drying temp. (^oC)	75	85	95	105	115	125	135	145
Drying const. (K_s)	0.020	0.033	0.036	0.037	0.041	0.067	0.073	0.089
R^2	0.982	0.974	0.903	0.966	0.965	0.956	0.977	0.996

From table (1), it can be seen that the values of the drying constant (K_s) varied with the drying temperatures in which it was increased with the increase of drying temperature. The dependence of drying constant (k) on the experimental parameters of heating surface temperature (Ts) and the exposure time (t) was also further studied using the stepwise multiple regression analysis. It was found that, the drying constant (k) was dependent strongly on the cylinder surface temperature as shown in the following equation:

$$K_s = - 0.0529 + 0.0009\ T \qquad (7)$$

$$(R^2 = 0.91)$$

Drying curves:

The applicability of the simple drying equation for describing the drying behavior of sunflower seeds and predicting the change of moisture content during the drying process was examined under different levels of drying temperature and exposure time. The observed and the calculated values of moisture content are presented in Table (2). Also, Figure (4) illustrates the observed and the calculated moisture content of sunflower seeds in a 45^o linear diagram.

In general, the results show that, the reduction rate of seeds moisture content was dependent on the drying temperature and decayed exponentially with the increase of the drying time.

Table (2): Observed and calculated moisture content of sunflower seeds.

Time., min	3		6		9		12		15	
Temp., ^{o} C	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.
75^o C	27.48	26.7	25.85	25.8	24.32	23.7	22.89	22.3	21.54	21.2
85^o C	26.45	25.2	23.96	23.7	21.7	21.6	19.65	19.5	17.8	16.9
95^o C	26.53	23.6	24.09	21.9	21.89	19.8	19.89	17.9	18.07	16.2
115^o C	26.42	21.2	23.53	19.1	21.12	17.6	18.96	15.5	17.02	13.6
125^o C	23.41	19.2	18.77	16.6	15.04	13.7	12.06	9.6	9.67	8.2
135^o C	23.91	18.6	19.6	15.9	16.02	14.2	13.11	11.8	10.74	7.9
145^o C	22.31	16.5	17.05	13.7	13.03	9.9	9.95	7.6	7.6	5.8

Fungi inactivation during conduction heating:

Table (3) presents the change in fungal mortality level as related to the exposure time and the heating surface temperature. The results showed that, the high temperature conduction heating reduced the fungal load in high moisture seeds in an effective manner. Also, higher heating surface temperature and longer exposure time resulted in more fungal load reduction.

Table (3): Fungal count (colonies/g) as related to exposure time and drying temperature.

Drying temperature (^{o} C)	Exposure time (min)					
	0	3	6	9	12	15
75	2618	1`935	1687	1556	1390	1182
85	2621	1768	1611	1490	1256	1080
95	2632	1542	1423	1190	989	843
105	2629	1353	1225	1023	917	811
115	2635	1189	1085	973	874	712
125	2631	1050	919	850	733	601
135	2629	808	632	511	320	298
145	2627	621	397	295	153	102

As shown in the table, the average initial fungal count for sunflower seeds was about 2627colonies/g, and they decreased to a varied levels depending upon the heating surface temperature and the exposure time. In general, it can be said that, the accelerated drying using the conduction heating technique may be considered as an effective procedure for both seeds drying and fungal inactivation. This would be very beneficial for sunflower seeds which deteriorate in a short time after harvesting due to the actions of both higher moisture content and higher fungal load

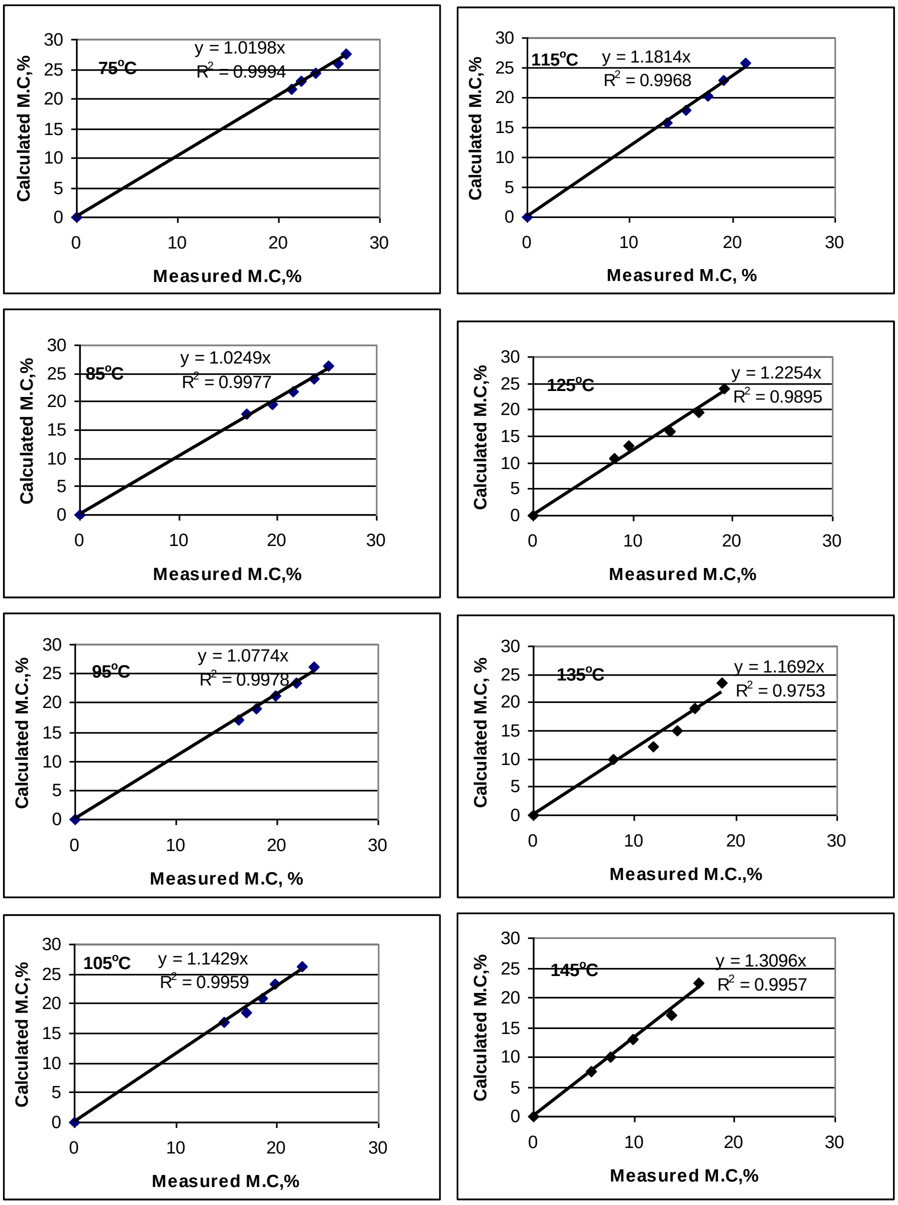

Figure (4): A typical 45 degree plot of the observed and the calculated moisture content using the simple exponential equation.

Free Fatty Acids (FFA%) in the extracted oil:

The presence of lipase enzyme in sunflower oil hydrolysis it into free fatty acids and glycerol. Also oxidation of free fatty acids leads to produce various off odor compounds such as aldehydes and ketons. The free acids tests were conducted only for the samples which approached the safe storage moisture content of sunflower seeds in the range of (5-7 % w.b). Table (4) illustrates the change in percent free fatty acids in relation to heating surface temperature and exposure time.

Table (4): Percent of free fatty acids, oil, acid value and peroxide value as related to heating surface temperature and exposure time.

Heating surface temp., °C	Drying time, min.	Seeds bulk temp., °C	Oil, %	F. F. A., %	Acid Value	Peroxide value
75	3	53.6	47.7	2.28	4.53	8.9
	6	60.5	47.4	2.31	4.59	9.6
	9	69.6	48	3.23	6.42	9.35
	12	70.8	47.1	3.34	6.65	4
	15	72.8	47.8	4.13	8.22	9.52
85	3	62.1	45.6	2.73	5.42	10
	6	71.9	52.8	2.65	5.27	5.49
	9	74.2	45.7	2.54	5.05	3.79
	12	79.3	50.6	2.52	5	10.9
	15	81.5	46.9	1.74	3.45	10.28
95	3	71.5	45.1	4.23	8.42	14.98
	6	74.6	45.9	3.81	7.57	2.89
	9	76.2	53.8	3.21	6.37	8.66
	12	81.4	48.8	2.15	4.28	4.27
	15	87.7	45.2	2.61	5.18	15.22
105	3	73.9	45.6	3.31	6.57	3
	6	79.5	49.5	3.82	7.59	6.9
	9	85.1	47.3	2.92	5.8	8.9
	12	89.7	46.5	2.31	4.59	5.4
	15	93.5	50	2.99	5.95	5.34
115	3	81.1	48.6	4.74	9.43	10.37
	6	87	48.7	3.32	6.61	10.82
	9	90.5	45.9	2.73	5.43	8.83
	12	96.9	47.7	4.6	9.3	9.43
	15	99.3	49.2	3.47	6.9	8.2
125	3	84.3	44	2.13	4.24	4.68
	6	91.7	47	2.42	4.82	5.48
	9	95.6	43.4	2.29	4.55	4.84
	12	103.4	41	1.81	3.6	5.6
	15	110.2	45.2	1.74	3.46	8.64
135	3	88.8	44	2.73	5.43	10.15
	6	93.5	42.7	3.07	6.11	10.25
	9	97.6	47.8	3.3	6.75	9.17
	12	106.8	43	3.2	6.38	8.24
	15	113.9	47.6	2.81	5.57	9.25
145	3	93.8	45.7	2.7	5.45	11.97
	6	98.2	42.4	2.46	4.89	11.5
	9	102.6	45.3	2.36	4.7	12.6
	12	118.4	40.2	2.46	4.8	12.8
	15	131.2	42.5	1.97	3.92	12.7

The results showed that, the free fatty acids of the control sample (sun dried seeds to a moisture content of about 6.85% (w.b.) approached a level of 17.56 % while it was ranged from 1.63 to 3.97 % for the heat treated samples. The observed increase in the percentage of free fatty acids in the control sample may come from the activity of lipase enzyme which causes a breakdown of a triglyceride into its components.

In general, it can be said that the heating surface temperature of 145^{o} C and the exposure times of 15 min decreased the moisture content of sunflower seeds to the safe level of 5.80% (w.b), with a fungal load of 102 colonies/g. (about 96% mortality level) and a percentages of free fatty acids of 1.97 %.

CONCLUSIONS

1-Seeds bulk temperature increased with the increase of exposure time and approached levels lower than that of the heating surface temperature.
2- Rapid moisture removal from seeds was clear in all experiments particularly at higher heating surface temperature and longer exposure duration.
3- The simple drying equations satisfactorily described the drying behavior of sunflower seeds.
4-The accelerated drying using the conduction heating technique considerably decreased the fungal load and the percentage of free fatty acids.
5- Heating surface temperature of 145^{o} C and the exposure time of 15 min are recommended to decrease the moisture content of sunflower seeds to the safe level of 5.8% (w.b), the fungal mortality level to about 96% and the percentages of free fatty acids to 1.63 %.

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التجفيف السريع والتثبيت الحرارى لبذور وزيت عباد الشمس

احمد محمود معتوق[1] , محمد مصطفي الخولى[2] , سلاف سيد عبد الرحيم [3]
[1] قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة
[2] قسم هندسة التصنيع والتداول - معهد بحوث الهندسة الزراعية- الدقى – جيزة
[3] معهد بحوث الهندسة الزراعية- الدقى – جيزة

أجريت هذه الدراسة على بذور عباد الشمس ذو المحتوى الرطوبى المرتفع لاختبار وتقييم تأثير عملية التجفيف السريع لفترات زمنية قصيرة باستخدام مجفف دورانى على المحتوى الرطوبى للبذور، الحمل الفطرى على سطح البذرة، وكذلك نسبة الأحماض الدهنية الحرة فى الزيت المستخلص كمؤشر لعملية التثبيت الحرارى للزيت. وقد شملت المتغيرات التجريبية 8 مستويات لدرجة حرارة سطح اسطوانة التجفيف (75 ، 85 ، 95، 105، 115، 125، 135، 145 درجة مئوية) وكذلك 5 مستويات لزمن تعرض البذور للحرارة (3، 6، 9، 12، 15 دقيقة). أظهرت النتائج المتحصل عليها أن عملية التجفيف قد تمت خلال مرحلة معدل التجفيف المتناقص، كما أن المحتوى الرطوبى للبذور قد تناقص بصورة سريعة حيث زاد معدل التجفيف بزيادة كلا من درجة حرارة سطح اسطوانة التجفيف وكذلك زمن التعرض. من ناحية أخرى أمكن لمعادلة التجفيف البسيطة وصف عملية التجفيف والتنبؤ بالمحتوى الرطوبى للبذور بصورة مرضية ومتقاربة.أظهرت النتائج أيضا انخفاض الحمل الفطرى لبذور عباد الشمس بدرجات مختلفة حيث تأثرت بكل من درجة حرارة سطح اسطوانة التجفيف وكذلك زمن التعرض. أيضا انخفضت نسبة الأحماض الدهنية الحرة فى الزيت المستخلص من البذور المعاملة حراريا مما يبين تأثير مدى المعاملة الحرارية على التثبيت الحرارى للزيت المستخلص. وبصفة عامة، يمكن اعتبار نظام التجفيف السريع لفترات زمنية قصيرة باستخدام المجفف الدورانى الذى يعمل بخاصية التوصيل الحرارى المباشر مناسبا لخفض كلا من المحتوى الرطوبى للبذور، الحمل الميكروبى، وكذلك نسبة الأحماض الدهنية الحرة فى الزيت المستخلص. كما أن درجة حرارة سطح اسطوانة التجفيف والتى تعادل 145 درجة مئوية عند زمن تعرض يعادل 15 دقيقة قد أعطى محتوى رطوبى يعادل (5,8 على الأساس الرطب) أقل نسبة للأحماض الدهنية الحرة (1,97%) وأعلى نسبة لقتل الفطريات (96%).

قام بتحكيم البحث

أ.د /ياسر مختار الحديدى	**كلية الزراعة – جامعة المنصورة**
أ.د / عادل سالم السيد	**كلية الزراعة – جامعة قناة السويس**