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Soybean oil and soy flakes production simultaneous using newly screw press design

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Demand for oils and foods are increasing and environmental concerns, all these are led to the search for a new method to decrease energy consumptions and increase oil and flakes quality. Oil yield and extraction time were affected by extraction method of oil produced, the time influence and energy consumptions**.**This research aims to find optimum rotational speed and warming temperature of newly designed screw press to improve properties of producing flakes and oil from Egyptian soybean seeds. The different extraction temperature and speed will effect on time of extraction, oil yield, torque, and power of the motor. Thirteen samples were produced in bio-oil laboratories at Mechanical Engineering Department, National Research Centre, and Giza, Egypt. Soybean seeds produced oil and flakes by using screw press under different warming temperatures 50, 75 and 100 °C and motors speed 17, 25, 65 and 100 rpm. Two samples were roasting under temperature 150 °C for ten minutes and compare its result to samples without roasting**.**The result directed to add the new motor speed of 17 rpm and roasting two samples to get the optimum oil extraction yield and best flakes. Proceeding from the fact that the cake of soybean pressed are full of nutritional constituents, however in Egypt, which they are often discarded as a by-product. The maximum yield of soybean oil was about 17 % that gave tasty, healthy and low fatty acid soy flakes because its extracted oils are the maximum at screw speed 17 rpm and preheated temperature 100 °C for roasting seeds. These conditions related to minimum motor torque and power.

Keywords: Soy Flake; Design; Soybean; Soybean Oil; Screw Press

INTRODUCTION

Soybean oil can be extracted chemically or by using mechanical presses. Traditional edible oils value will be increasing with population growth all over the world, this leads to decrease losses in oil and energy. For that reason, directed a lot of research to increase the percentage of extraction oil, it is required to raise the yield of soybean oil and nutritional value of soy flakes (Atta and Imaizumi 2002; El-Baz et al., 2017; Gad and Abu Hashish 2018)

Mechanical extractions are continuous extraction way and its higher yield as an extraction process. It produces maximum yield of oil from seeds up to 20% (Ibrahim et al., 2017a, 2017b). The old oil extraction methods are manually and by use simple implements, it is using now less. Oil production methods are mechanically, chemically or enzymatically (Koh et al., 2011; Shah, Sharma, and Gupta 2005). There are new methods now are ultra-sonication and enzymatic. The most types of presses are Sayari and Komet expellers. Komet expeller is electrician expeller has single screw, it also used for extracts

oil from seeds (Kumar and Sharma 2008).

Small screw press was used to press seeds after preheating it. The electric motor has power 20 hp been used to drive this screw. The barrel diameter was 89 mm and its ratio between length and diameter is 8.3. Cage has 4 sections and every section is 140 mm (Evangelista, Isbell, and Cermak 2012; Evangelista and Cermak 2007). The rotating shaft was using to drive screw; it was supported by a conical shaft. The Hopper used to feed screw by oilseeds and press it in the barrel. the cakes will be passed from barrel end and oil will pass through small holes in the bottom of the barrel (Tambunan et al., 2012; Naeem, Abu Hashish, and Zahran 2017).

Mechanical extraction is the best method to take oil from seeds, especially variety groups of oilseeds (Hancock and Dock 1995). Equipment of mechanical extraction applied high pressure on soybean seeds to forced Lipid out seeds, this method can be applied to seeds has a high content of oil, it's known by the cold press (Irfan and Pawelzik 1999). Main parameters for mechanical extraction are temperature and pressure. The maximum oil can be extracted by using high pressure and temperature. Very difficult to obtain more than 10% of soybean oil at room temperature under high pressure (Li 1999). Soybean has low cost and high-quality proteins for this many of food products use in a wide source of protein (Zhang et al., 2003; Palazolo, Mitidieri, and Wagner 2003).

In additions, the advantage of screw press is selectivity, yield and with better processing. it also has decrease process time, the term productivity and enhanced quality. Screw press is eco-friendly and it will be reduced chemical and physical hazards. Screw machine extraction has been regarded as a green extraction process, for reasons including reductions in processing times, energy consumption and enhanced rates of extraction.

This study aim was to get the best rotational velocity and warm temperature of screw to obtain improved characteristics of extracted the effect of soybean seed treatment, extraction power and time.

MATERIALS AND METHODS

Materials

The seeds of soybean were obtained from local market June 2017 in Cairo, Egypt. The seeds were handpicked and grouped into two groups, the 1st group without roasting and the 2nd group is roasted with roasted temperature 150 C for 10 minutes. Soybean cake was used to produce flakes. The roasted and unroasted seeds as depicted in Fig. 1. Soy flakes were produced from by-products of soybean, it will be a good alternative to processed food because it rich by carbohydrate and nutritional protein. Figure 2 shows soy flakes for roasted seeds and seeds without roasting.

Methods

Soybean Oil and Soy Flakes Extraction Method

The screw press is continuous process, it is use to extract oil from seeds according to the method was designed (Ibrahim et al., 2017a). This screw press was designed and developed to produces soybean oil and soy flakes in the same time in one process. This will reduce power consumption and time to half. Screw press has control on temperatures and speed to try and give maximum oil yield and healthy soy flakes.

Experimental procedure

The experiments were sieved to oil and flakes by using screw press under different and warming temperatures 50, 75 and 100 °C and motors speeds 17, 25, 65 and 100 rpm. The result directed to add new motor speed of 17 rpm and roasting two samples under temperature 150 °C for ten minutes to get the optimum oil extraction yield and best flakes. The time of extraction, motor power, motor torque and extraction yield were calculated.

Motor power

Electric motor power is the rate of doing action, recorded in watts, and expressed by the letter (P). The power of electricity in watts generated by an electric current (I) consisting of a charge of Q coulombs per time (sec) passing through an electric potential (voltage) variation of (V). Power (P) in watts calculated according to the equation (Halliday and Resnick 1981):

$$P = IV\cos\theta \quad (1)$$

Where:

V is the voltage by V.

I is the current by A.

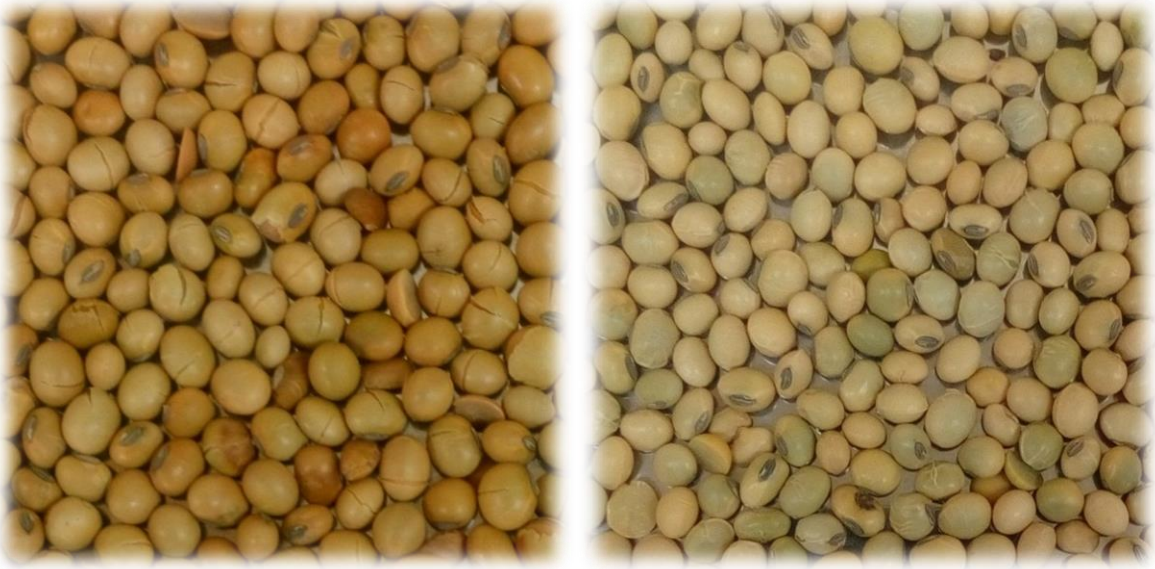
θ is the phase angle by ° .

Motor torque

The torque force can be thought of as a twist to an object., Also torque could be A vector value

to measure the power of a force to rotate the object around an axis, it could be calculated based on the following equation (Halliday and Resnick 1981):

$$T = \frac{60P}{2\pi N} \quad (2)$$

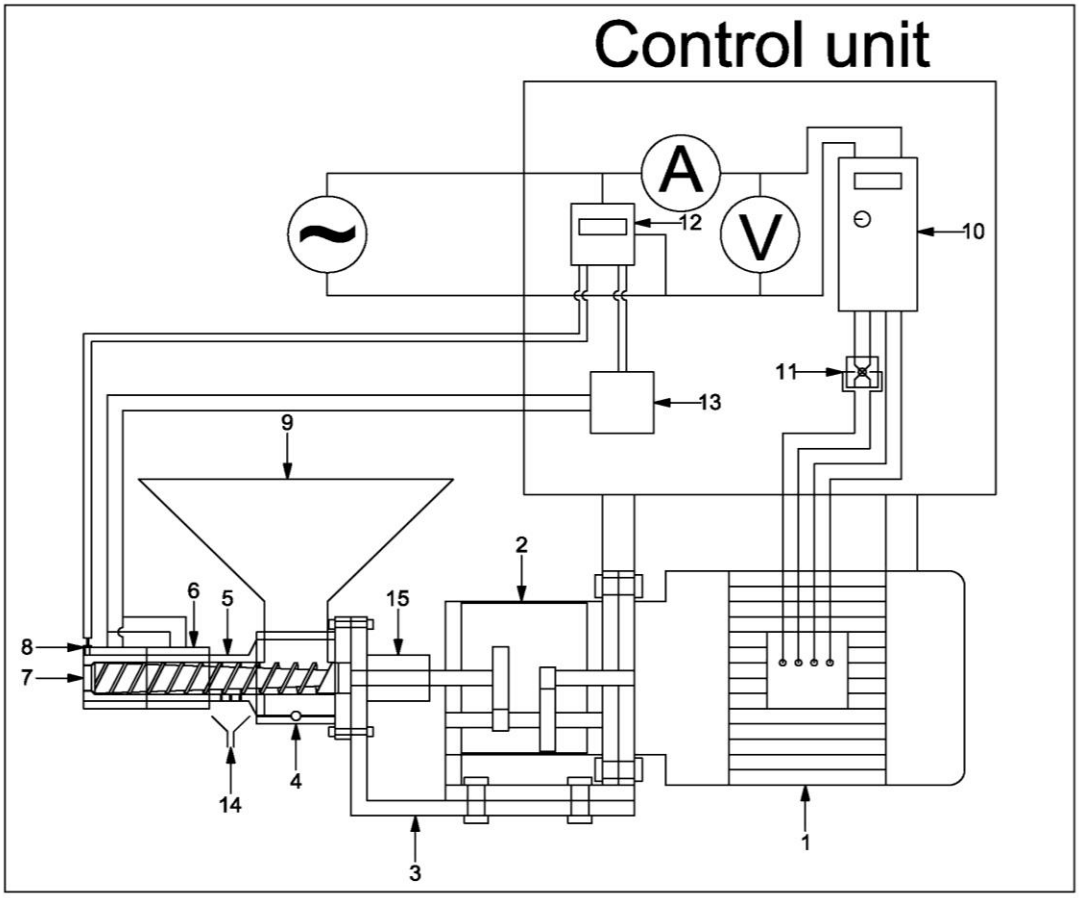


(a) Roasted seeds. (b) Seeds without roasting.

Figure. 1 Soybean seeds.

(a) Soy flakes for roasted seeds. (b) Soy flakes for seeds without roasting.

Figure. 2 Soy flakes



1	AC Motor	2	Gear box	3	Base A
4	Base B	5	Housing	6	Heaters
7	Screw	8	Temperature sensor	9	Feeding hopper
10	Inverter	11	Direction switch	12	Thermostat
13	Relay	14	Oil collector	15	Coupling

Figure. 3 New Design of screw press produces soybean oil and soy flakes and its parts.

Where:
P is power by W.
T is torque by Nm.
N is screw rotational speed by rpm.

Extraction yield

The percentage of oil content in soybean seeds can be calculated according the method described by(Forson, Oduro, and Hammond-Donkoh 2004):

$$Percentage\ of\ oil\ extracted = \frac{Weight\ of\ oil\ obtained\ in\ gm}{Weight\ of\ seed\ taken\ in\ gm} \times 100 \quad (3)$$

Chemical composition

Moisture, protein, Fat, ash and crude fiber contents were determined according to AOAC 2005 (Horwitz and Latimer 2005). Carbohydrates were calculated by difference as mentioned as follows [18]:

$$Carbohydrates = 100 - (\%\ protein + \%\ fat + \%\ ash + \%\ crude\ fiber) \quad (4)$$

RESULTS AND DISCUSSION

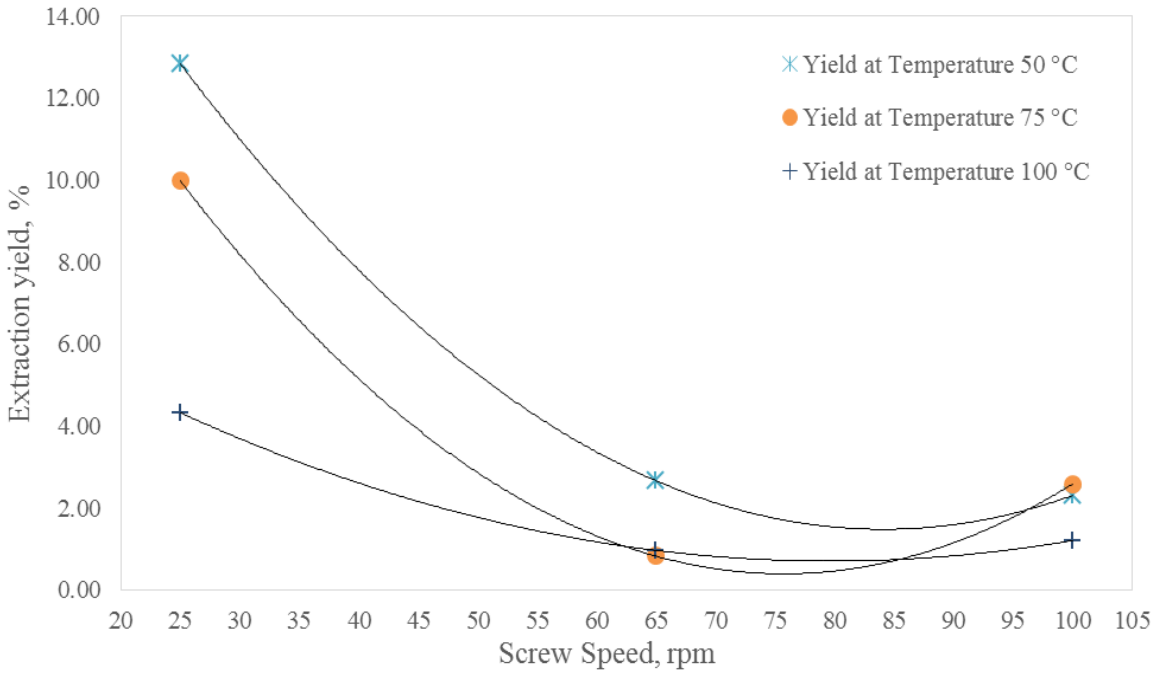


Figure. 4 Effect of pre-heating temperature and rotational speed on oil yield

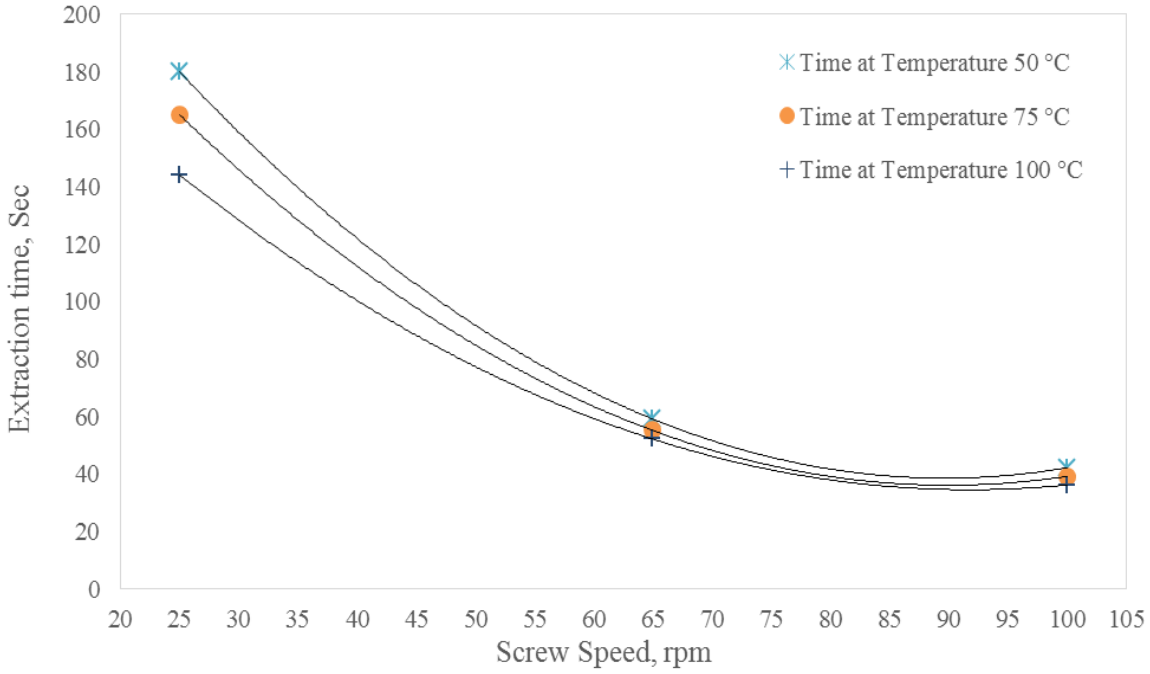


Figure. 5 Effect of pre-heating temperature and rotational speed on time of extraction

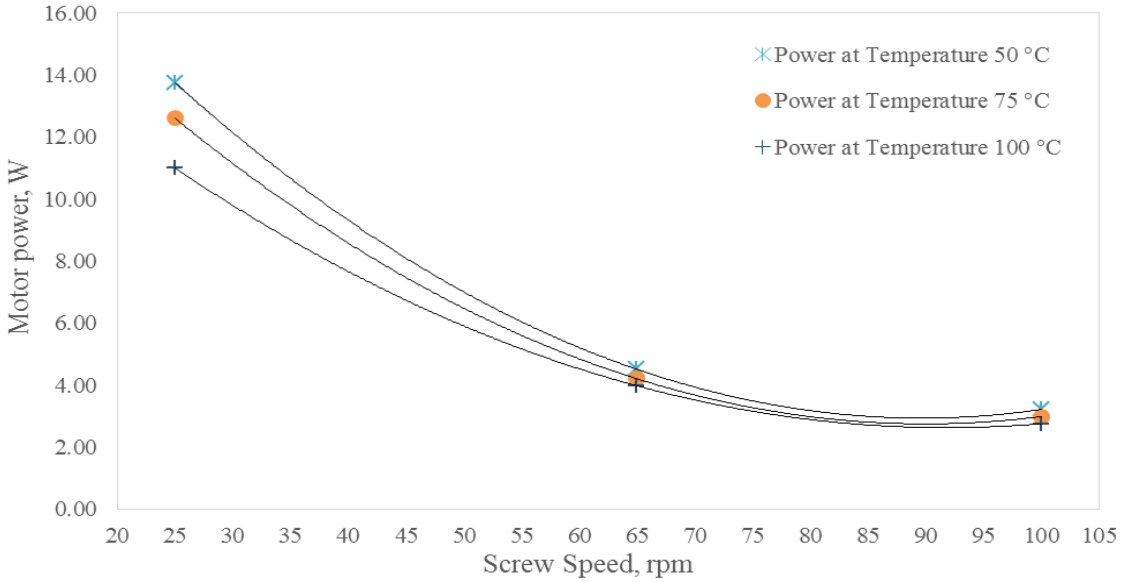


Figure. 6 Effect of pre-heating temperature and rotational speed on power of motor

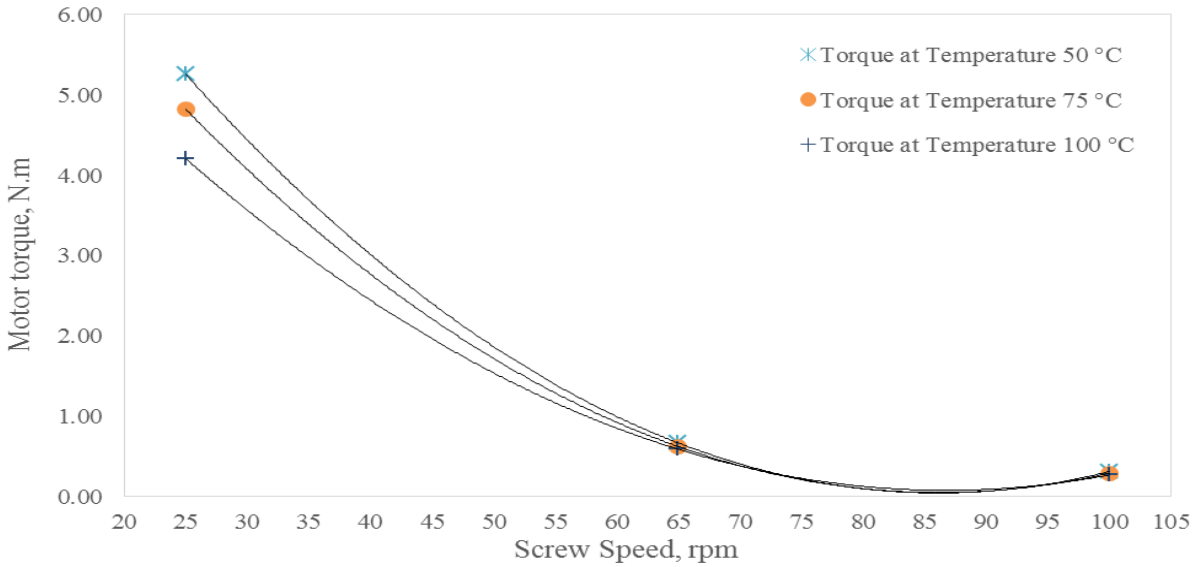


Figure. 7 Effect of pre-heating temperature and rotational speed on torque of motor

Effect of pre-heating temperature and rotational speed on oil yield

The results revealed that the maximum extraction yield from soybean oil by Soxhlet about 18%. As shown in Fig.1 the results indicated that the maximum oil yield was about 12.84 %, it was produced at a motor speed of 25 rpm and warming temperature of 50 °C. This proved that screw press was effective. Form the figure 4 can note oil yield increased by decreasing motor speed. This led to select another motor speed and roasted two groups of seeds on temperature 150 for 10 min. New motor speed give maximum oil yield is 16.34 at 17 rpm and 100 °C for roasted seeds as shown as in table 1, soy flakes for this condition were tasty, healthy and low fatty acid because its extracted oils are the maximum.

Effect of pre-heating temperature and rotational speed on time of extraction

The time of extraction is the same approximately at all extraction temperatures at rotational speeds ranged from 65 to 100 rpm. The time of extraction decreased by uprising temperature at lower speed as shown in Figure 5.

The best time for tasty and healthy soy flakes give maximum yield at 17 rpm speed and temperature of 100°C was 516 sec for roasted seeds as shown in Table1.

Effect of pre-heating temperature and rotational speed on power of motor

The power of motor was the same approximately for all warm temperatures at rotational speeds ranged from 65 to 100 rpm. The power of motor increased with temperature decreased at lower speed as shown in Figure 6. The less power for tasty and healthy soy flakes give maximum yield at 17 rpm speed and temperature of 100°C was 39.41 W for roasted seeds as shown in Table 1. Power was high and motor will stop if speed decreases less than 17 rpm.

Effect of pre-heating temperature and rotational speed on torque of motor

The torque of motor was the same approximately for all temperatures at rotational speeds ranged from 65 to 100 rpm. The force of torque increased by temperature increasing at lower speeds as shown in Figure 7. The less torque for tasty and healthy soy flakes give maximum yield at 17 rpm speed and temperature of 100 °C was 22.15 N. m for roasted seeds as shown in Table 1.

Optimizing extracted oil yield of the screw press

The maximum oil yield from measurements was 16.34% at a rotational speed of 17 rpm and warming temperature of 100 °C for roasted seeds, this give minimum fat in soy flakes and it healthy. Temperature and speed increasing led to power decreasing, time and yield of extraction. Low speed and temperature increased extraction yield. The lowest oil yield is 0.82% at a speed of 65 rpm and temperature 75 °C, these give maximum fats in soy flakes and it not healthy. Higher speeds and temperature resulted in lower oil yield as presented in Table1.

Chemical Composition of Soybean Flakes

Table 2 shows the chemical composition of soybean flakes, which indicates that these soybean flakes contain a high percentage of protein, carbohydrate and mineral. Palazolo et al found that Soybean protein has been widely used as a source of high-quality proteins in many food products because of its excellent functional properties and low cost (Palazolo, Mitidieri, and Wagner 2003)

Low motor speed and mean temperature 100 °C for roasted seeds will improve. Roasted soybean seeds and press under temperature of 100 °C, at motor speed of 17 rpm give soy flakes best protein 30.625 %, carbohydrate 23.7 %, nitrogen 4.9 %, potassium 0.65 %, Calcium 0.2 %, ferrous 307.7 ppm, zinc 22.2 ppm, manganese 26.9 ppm.

Table 1 The experimental results of Time (Sec), power (W), torque (Nm), yield (%) and type (Roasted or not), at different extraction temperature and speed*.

No.	Speed	Temperature	Time	Power	Torque	Yield	Type
	"RPM"	"°C"	"Sec"	"W"	"Nm"	"%"	
1	100	50	42	3.21	0.31	2.3	Unroasted
2	100	75	39	2.98	0.28	2.58	Unroasted
3	100	100	36	2.75	0.26	1.2	Unroasted
4	65	50	59	4.51	0.66	2.66	Unroasted
5	65	75	55	4.2	0.62	0.82	Unroasted
6	65	100	52	3.97	0.58	0.96	Unroasted
7	25	50	180	13.75	5.25	12.84	Unroasted
8	25	75	165	12.6	4.82	9.98	Unroasted
9	25	100	144	11	4.2	4.32	Unroasted
10	17	50	430	32.85	18.46	12.14	Unroasted
11	17	100	530	40.48	22.75	9.18	Unroasted
12	17	50	144	11	6.18	9.08	Roasted
13	17	100	516	39.41	22.15	16.34	Roasted

*The samples have sorted according to rotational speed and temperature of extraction

Table 2 Chemical Composition of Soy Flakes.

No.	Speed "RPM"	Temp. "°C"	Type	Protein "%"	Carbohydrate "%"	N "%"	P "%"	K "%"	Fe "ppm"	Zn "ppm"	Mn "ppm"	Cu "ppm"
1	17	50	**Unroasted**	3.9375	26.4	0.63	0.07	0.05	524.3	3.3	8.2	2.5
2	17	50	**Roasted**	34.5625	19.8	5.53	0.63	0.19	264.6	23.1	22.9	15.3
3	17	100	**Unroasted**	2.1875	17.9	0.35	0.05	0.02	2110	1.1	30.1	1.6
4	17	100	**Roasted**	30.625	23.7	4.9	0.65	0.2	307.7	22.2	26.9	17.3

CONCLUSION

The results could be concluded:

New screw press introduced reliable and successful to oil extraction and flakes from Egyptian soybean seeds with optimum yields for various operating conditions.

The optimization of oil yield related to temperature, time, power, torque and roasting seeds.

The High temperature of extraction and rotational speed decreased oil yield but also decreased the motor torque, time of extraction and motor power.

Low extraction temperature and screw speed increased oil yield.

Low extraction temperature and screw speed increased oil yield. The optimum yield is 16.34% at time 516 Sec, speed 17 rpm temperature100 °C, power 39.41 W and torque 22.15 Nm.

The extraction temperature of 100 °C, at motor speed of 17 rpm gives the maximum yield and the best flakes quality and testy.

The optimum yield is 16.34% give soy flakes were tasty, healthy and low fatty acid because its extracted oils are the maximum.

Low motor speed and mean temperature 100 °C for roasted seeds will improve soy flakes and it contain a high percentage of protein, carbohydrate and mineral

Roasted soybean seeds and press under temperature of 100 °C, at motor speed of 17 rpm give soy flakes best protein 30.625 %, carbohydrate 23.7 %, nitrogen 4.9 %, potassium 0.65 %, Calcium 0.2 %, ferrous 307.7 ppm, zinc 22.2 ppm, manganese 26.9 ppm.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest".

AUTHOR CONTRIBUTIONS

H. M. Abu Hashish designed and performed the experiments and also wrote the manuscript. Amal E. Abd El-Kader designed experiments and reviewed the manuscript. All authors read and approved the final version.

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