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Design and Optimization of Press Machine in Order to Produce Sesame Oil

Abbas Akbarnia*, Mahdi Rashvand

Machine Design and Mechatronics Department, Institute of Mechanics, Iranian Research Organization for Science and Technology, Tehran, Iran

Email address:

abbasakbarnia@irost.ir (A. Akbarnia)

*Corresponding author

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Abstract: Due to the high demand of the Iranian people for sesame oil and also the country's high potential for land cultivation, it was necessary to design a device with desirable application that could confront this need. The used device in this research has the ability to extract high-efficiency oil as well as economically feasible. According to the results, increasing temperature cause increasing the peroxide and acidity of sesame oil. Also, increasing the temperature will reduce the moisture content of the sesame in the machine, which somewhat changes the quality and quantity of oil output from the machine. Increasing moisture content reduces the amount of peroxide and acidity of the oil, but also has an effect on the amount of extracted oil of the machine increasing the temperature increases the combustion of air oxygen with oil, which increases the amount of peroxide and acidity of the oil. Overall, preserving the quality of food is more important than quantity In order to evaluate the output of sesame oil, the peroxide and oil acidity values were measured. The test variables were also the velocity of the helix (0.4 and 0.8 Hz) and the temperature of the chamber (30 and 60°C). According to the obtained results, the highest quality of oil extracted at the speed of 40 Hz and 40°C, as well as at 0.8 Hz and 60°C of press compartment, had the lowest percentage of residual fat in the meal.

Keywords: Press Machine, Sesame Oil, Velocity, Temperature

1. Introduction

The importance of oily seeds is not only due to the oil present in them, but also because of the valuable protein substances that are consumed after extraction of oil in human nutrition [1]. Oily seeds are one of the most valuable products in world trade and are the second most important agricultural product after meat and cereals [2]. Also, today, new sources of fossil fuels have been introduced in the internal engines. Yearly, significant amounts of the country's currency resources are spent on the import of food products, with sesame oil being nationally valued in the context of a very large market for consumption [3]. Increasing the production of edible oils can be achieved in addition to improving the cultivation and cultivation practices of high yielding cultivars by improving the systems used at various stages related to the seeds, including the extraction oil system [4].

Sesame seeds is one of the most important and oldest oily seeds that grows in tropical and subtropical areas with dry and rainy weather [5]. This seed is a rich source of oil (44%) and protein (20-33%). Therefore, the most use of this grain is to extract and produce the oil contained [6]. This oil has a mild flavor and a pleasant taste. The protein contained in it has an index rich in amino acids, and it has a very nutritional value, like the protein of soybeans. Sesame oil is known as a price and high quality oil [7]. Sesame oil is known as a price and high quality oil. This oil has a long and lasting resistance to high-fat unsaturated edible oils. The natural antioxidants in this oil have a high resistance to oxidation and valuable physiological properties of sesame oil. Sesame oil is one of the unsaturated and useful oils for humans, and it has been proven that this oil can lower human cholesterol levels [8].

In the technology of edible oils, extraction of oils and fats from plant and animal resources is a specialized branch.

Diversification in oil extraction technology is often due to the diversification of its supply sources. Today, oiling methods play a significant role in the quality of oil. These methods include mechanical extraction, solvent doping [9], roughingery by mechanical method, and Solvent Extraction by Soxhlet [10], Extraction by Superconducting [11], Microwave Extraction [12], extraction by supercritical fluid [13].

Reshma et al (2010) carried out a research about Extraction, separation and characterization of sesame oil. In the study they have aimed at separating lignans from sesame oil aiming at use as nutraceuticals. Sesame oil was subjected to sequential extraction with methanol under selected conditions of temperature (70°C), time (100 min) and solvent. According to the above mentioned, it can be claimed that the localization of the technology of designing and manufacturing of oiling machines is of great importance due to the foreign exchange and economic problems of importing foreign samples. By manufacturing of oil extraction machines, it is possible to produce internal oil which led to a solution to reduce dependence on oil imports. This is as much as 90% of the country's oil is imported through imports. Therefore, the requirement for long-term planning with the aim of achieving self-sufficiency in edible oil production is indisputable.

Due to the domestic production of oilseed rags, the extracted oil supplies only 15% of the country's total consumption; in 2010, 220,000 tons of oil was imported into the country, of which 420,000 tons of oil The crude oil valued at $ 200 million and 100,000 tons of finished oil worth $ 100 million. The purpose of this research is to design, manufacture and evaluate a machine for extracting sesame oil.

2. Material and Methods

In this research, physical and mechanical properties of Iranian sesame were studied. All specimens were bought from market and then transferred to the laboratory for physical properties and maintained for 24 hours in the refrigerator to ensure uniformity of moisture. After 24 hours, the samples were quieted from the refrigerator and use moisture content (equation 1) based on the fruit Standard warm air method was performed by placing 3 repetitions of 20 grams from each variety at a temperature of 101°C.

$$w_w = 100(\frac{m_w - m_d}{m_w}) \tag{1}$$

m_w: Primary mass in pre-dry condition

m_d: Secondary mass or mass of dried product

2.1. Physical and Mechanical Properties

The length, width and thickness are respectively the largest, mid, and smallest diameter of the seeds, which are arranged in three axes. These diameters were measured in 10 randomly selected seeds by digital caliper with a precision of 0.01 mm. Generally, the criterion used to describe the shape of the fruit is the spherical coefficient, which is calculated from equation (2, 3).

$$D_g = (abc)^{\frac{1}{3}} \tag{2}$$

D_g: Geometric mean diameter of sample, a: length of sample, b: width of sample, c: thickness of sample

$$\emptyset = \frac{D_g}{a} \times 100 \tag{3}$$

That $\emptyset$: Sphericity coefficient of sesame

Similarly, a mechanical factors about Iranian sesame seeds, which was needed in the design of the machine, was carried out by the necessary tests. For this purpose, the rupture force, rupture energy, deformation at the moment of rupture, rigidity and modulus of elasticity were determined by the device (HOLINSFIELD H5KS).

2.2. Feed rate of the Device

The most important part of the oil extraction plant is the helix. The duty of the gel actually causes the impact on the seed of sesame and breaking it, as well as the forward crushed seed mass. The amount of processing operation at this stage depends on the type and size of the helix and the space between the helix and the crust. The machine must be designed in the long run so that the seeds are crushed and the oil in the oil outflow separates a large amount of oil from the mass. In the oil industry, the spiral is designed to have the maximum pressure on the grains due to reduced depth. Equation 4 can be used to calculate the feed rate of the device.

$$Qs = V.\rho \int_{\frac{Ds}{2}}^{\frac{Db}{2}} (2\pi R - \frac{me}{sin\theta})dR \tag{4}$$

Where Q_S is the feeding rate (kg / day), m the number of winding points (in this machine m = 1), ρ density of materials (kg / m3), D_b outer spiral diameter (m), Ds outer diameter of the helical axis (m), E is the thickness of the extruder screw and θ the angle of the helix in the oil extraction device.

Based on the spiral equation on the helix, we can express the equations 5, 6 and 7, where x, y, z are axes of the coordinate axis of the device. Here tangent tangent is the curvature angle. The magnitude of the angle α in the extruders is 17 °.

$$x= (r+mL)\cos\theta \tag{5}$$

$$y= (r+mL)\sin\theta \tag{6}$$

$$z= (r+mL)\cot\theta \tag{7}$$

The length of the spiral curve is defined by a relation denoted by x, y, z, in which S is the length of the spiral curve (equation 8).

$$S^2= x^2+ y^2+ z^2 \tag{8}$$

Also, the displacement volume can also be obtained by the equation 9. Where V_a is the volumetric flow rate inside the helix (m^3), B is the channel of the channel (m), H is the empty space between the gel and the inner surface of the shell (m) and S is the length of the helix (m). (Figure 1)

$$V_a = B.S.H \quad (9)$$

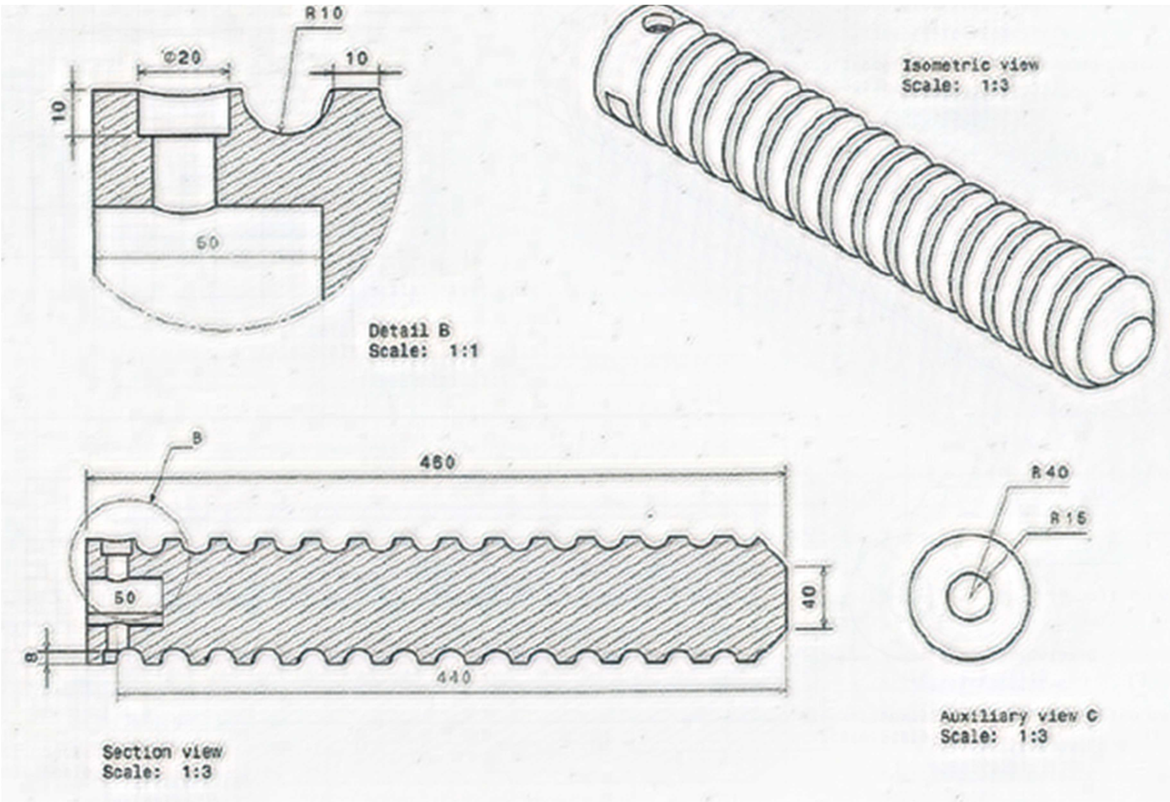

Figure 1. *Simulated model of helicase.*

2.3. Compartment of Device

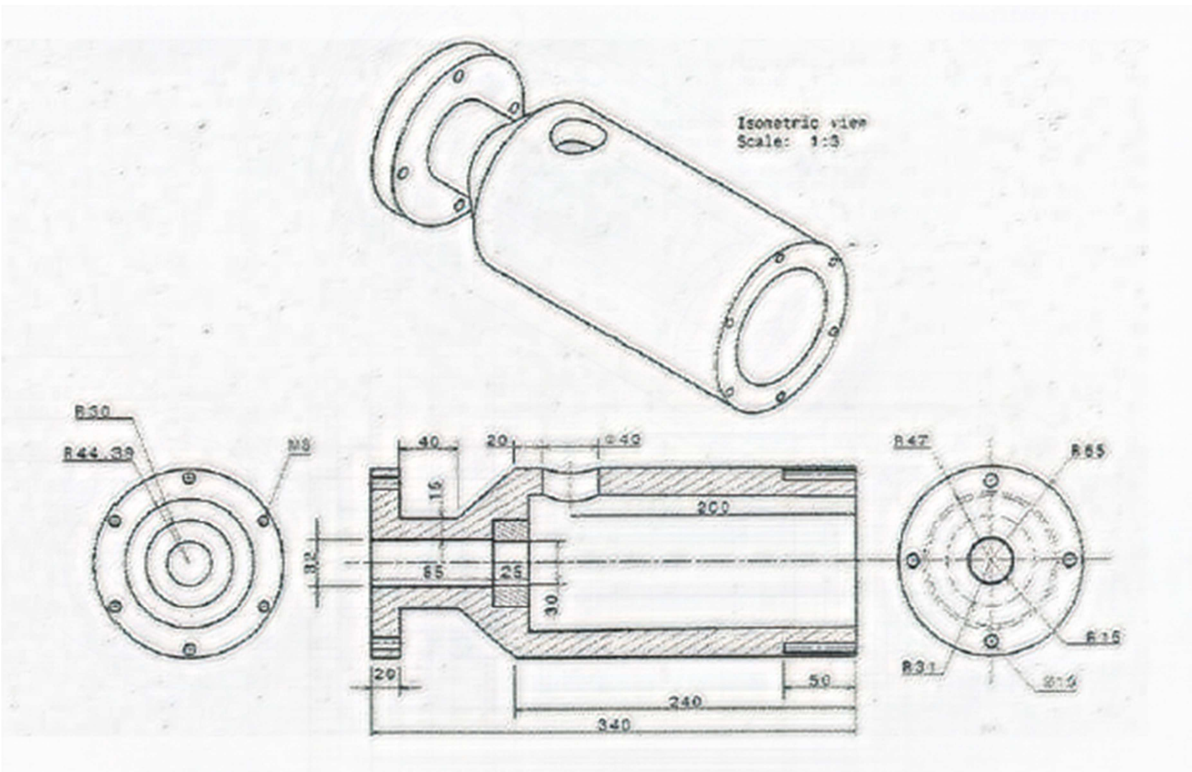

Figure 2. *Simulated model of compartment.*

The compartment contains the main chamber and the feeding tube (Figure 2). The shell is connected to the gearbox on one side and on the other side to the oil outlet. To calculate the shell thickness of the lubrication system, the radial stress and tangential stress on the tank wall are calculated from equations 10 and 11, respectively.

$$\sigma_r = \frac{r^2\, i\, Pi}{r^2\, o - r^2\, i}\ \left(1 - \frac{r^2\, o}{r^2\, i}\right) \quad (10)$$

$$\sigma_t = \frac{r^2\, i\, Pi}{r^2\, o - r^2\, i}\ \left(1 + \frac{r^2\, o}{r^2\, i}\right) \quad (11)$$

Where p_i is the pressure inside the reservoir, r_i, the radius inside the reservoir r_o, the outer radius of the reservoir, σ_r, the radial stress enters the reservoir wall (MPa) and tangential tangent to the shell of reservoir (MPa).

To remove oil from the chamber, there is a need for an element on which there are radial holes. During the process of seed treatment and crushing inside the machine and the process of heat treatment of the oil from the seed, through this pore, oil can be transferred to the oil collecting container.

2.4. Engine Power

The task of the drive axis is to establish the relationship between the gear box with the gel and the torque transmission required to start the engine, as obtained from equation 12, in which G is the stiffness modulus (GN/m^2), L axis length, β angular deformation in radians, and J is the polar inertial momentum is. By determining the torque, the power is calculated from equation 13 for maximum velocity, in this case t is the torque, n per minute, and p is the power (KW).

$$T = \frac{G\beta J}{L} \quad (12)$$

$$P = \frac{2\pi n T}{60} \quad (13)$$

2.5. Heating System

The heating of oilseeds increases its compressibility and reduces the oil pressure of the oilseed. Research results show that increasing the amount of heat, the amount of oil extraction also increases. In this regard, various studies have been carried out that can be used to research of evangelista (2009) and eggers et al (2006) Considering the importance of the heating process to the amount of oil extraction, the design of the heater system was also important in modeling the effective surface of the heat element and the shell of the heating element. In the Figure 3 the location of the heating element is observed on the outer surface of the shell of the carrier.

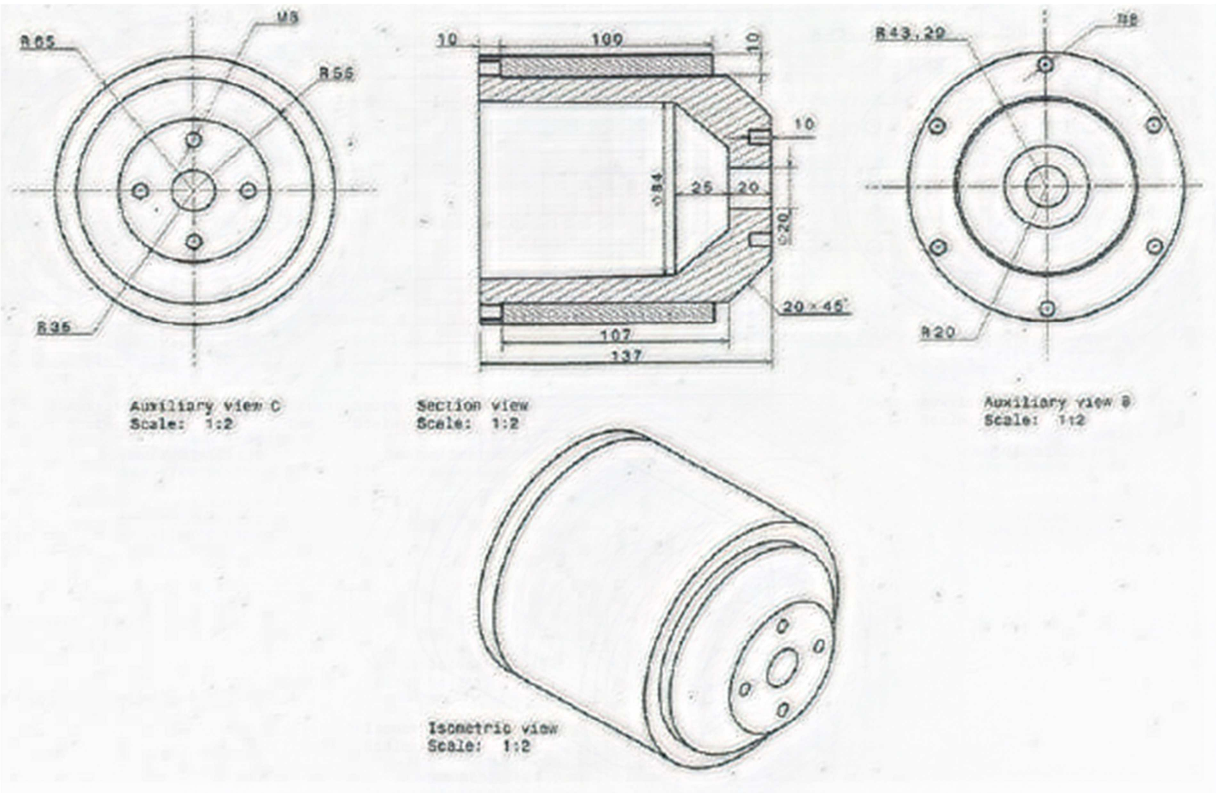

Figure 3. *Simulated model of heating system.*

2.6. Press of Device

As the last part in the oil extraction machine, it is effective in extracting oil and feed type as well as the internal pressure of the machine. Its performance is similar to that of a meat grinder, which, by creating pressure in the outlet, causes the material to flow out of the vapor ducts.. In the inner part of the dye, a cone has been created (Fig. 4). The existence of an angle creates a convergent channel, which facilitates the flow of the meal to the extruder end enclosure. Due to the squeezing of the oil and the exhaust of the oil at the end of the extruder, the oil can be directed to a more open area and, as a result, reverses the oil, which increases the amount of oil extraction. Researchers such as 2009 Ferchal stated that reducing diameters of resistors on the way to the output of greasy meals would increase the pressure, which in turn results in more oil being removed. Therefore, reducing the diameter of the dye can increase the oil extraction. In fact, decreasing the diameter of the dithia causes an increase in the pressure level in the space between the glycerin and the dyed, which results in a reverse effect on the discharge of the meal and reduces it. The diameter of the output, the number of output pores, and the output of the die, are the most important factors in the performance of the processing machine.

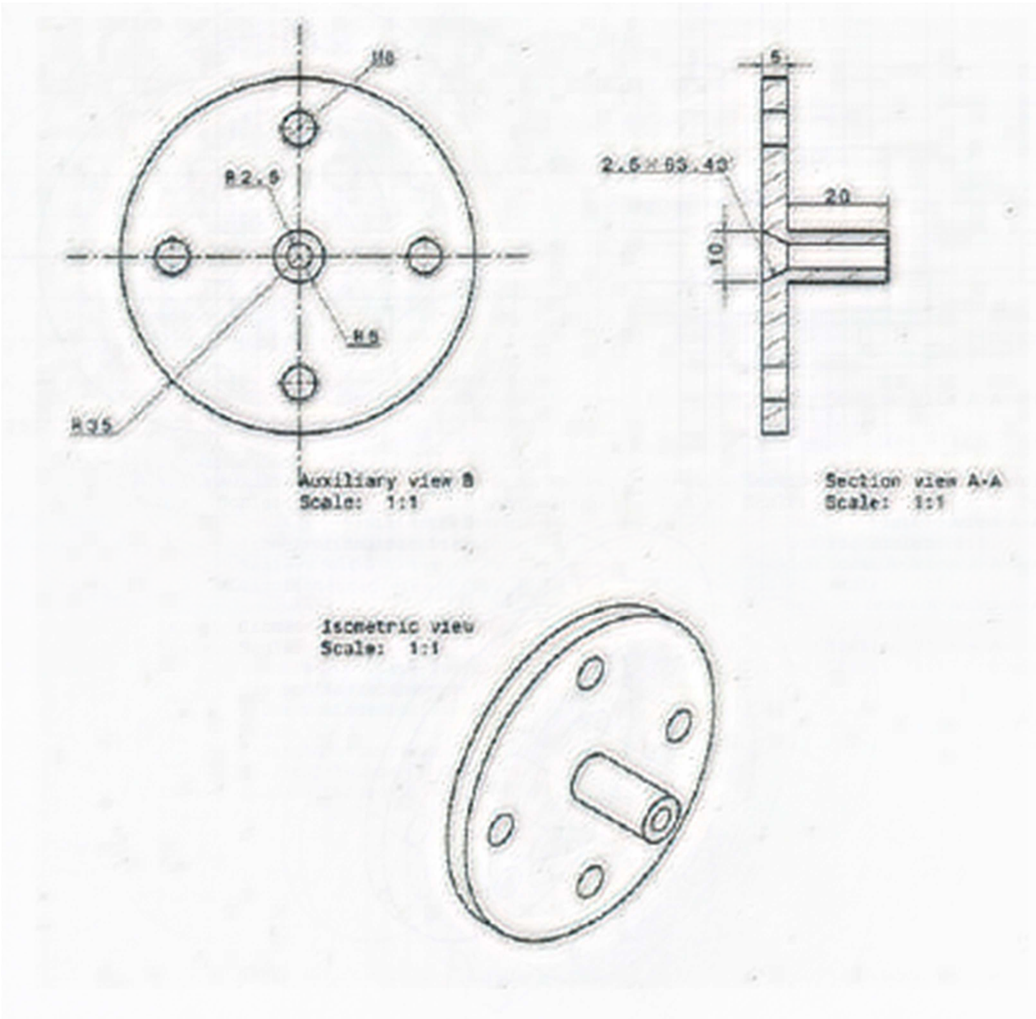

Figure 4. Simulated model of press system.

2.7. Evaluation of Device

To obtain pure sesame oil of good quality and quantity, experiments were carried out at different levels. In this research, the velocity of the spiral shaft at 0.4and 0.8 Hz speeds were considered, 30° C and 60°C were consider as temperature of compartment. Also, for evaluation of extracted oil, two important factors of oil (acidity and peroxide value) were measured.

3. Results and Discussion

3.1. Physical and Mechanical Properties

Table 1 shows the average physical properties of sesame seeds. Table 2 also shows the amount of maximum and minimum of mechanical properties sesame samples.

Table 1. Average physical properties of sesame samples.

Property	Length	Width	Thickness	Moisture	Geometric mean diameter	Sphericity coefficient
Value	3.24	1.82	0.91	3.98	1.74	53.89

Table 2. Max and min mechanical properties of sesame samples.

Mechanical Properties	Max	Min
Deformation at the moment of rupture(mm)	0.834	0.426
Rupture Force (N)	88.57	46.66
Rupture Energy (J)	0.033	0.015
Elasticity Module (MPa)	278.9	66.53
Stiffness (N/mm)	63.96	182.55

3.2. Components of Device

In the device, the effective length of the extruder was 390 mm and the step of 30 mm gel. Also the thickness of the 10 mm hollow tooth, the outer diameter of 80 mm and the angle of the helix were 82.5°. Considering the depth of the spiral tooth In the model, it varies, eventually with a feed rate of 239.02 kg per day (10 hours of work per day). The length of the hay screw curve is 3428.5.

To maintain safety and a higher degree of certainty, the thickness of the tooth was considered at its critical point of 10 mm. Due to the structure of the design of the sesame oil extractor system, the thickness of the crust is not uniform in order to connect different parts to each other and also to increase the resistance, and gradually increased from the beginning of the extruder to the output of the machine. So that the thickness at the beginning of the shell is 15 mm and at the end to a small 25 mm.

3.3. Evaluation of Peroxide and Acidity

The oil and oil peroxide values were extracted to determine the quality of the product and the amount of oil remaining in the corn was determined to determine the amount of oil obtained. According to the obtained results, the velocity of the helical duct and the temperature of the press compartment and also the effect of the velocity of the spiral droplet and temperature of 1% on the acidity of the oil were significant. Also, spur rotational speed and pressure of the press compartment at 1% level were significant for peroxide value, but the interaction between spiral and temperature was not significant on peroxide value. According to the results, spiral rotary velocity and pressure chamber temperature at 1% level were significant on the amount of residual fat in sesame meal. Also, the interaction of spiral rotational speed and temperature on the amount of residual fat in meal was significant at 5% level. It should be noted that in all cases, repetition did not significantly affect itself (Table 1).

Comparison of the mean acidity of sesame oil extracted in different treatments of spiral shaft speed and press compartment temperature, based on Duncan's multi-domain test at 5% level. Based on the results of 0.4 Hertz, the spiral number of oil acidity at rotational speed of 0.4°C is 30°C. The temperature of the press compartment is less than that which indicates the better quality of the oil extracted in these conditions. The acidity of the oil at a rotational speed of 0.8 Hz and a 60°C pressure in the press compartment indicates a greater amount, indicating poor quality of the oil.

The average value of the amount of peroxide of sesame oil extracted in different treatments of spiral shaft rotational speed and press compartment temperature based on Duncan's multiple range test at 5% level. As it can be seen, four rotational speeds of 0.4 and a temperature of 30, a rotational speed of 0.8 and a temperature of 30, a rotational speed of 0.4 and a temperature of 60 and a rotational speed of 0.8 and a temperature of 60 were very different.

The comparison of the remaining fat content of the meal in accordance with Table 5 shows that increasing the speed of the spiral shaft at a constant temperature of 30°C in the press compartment results in a significant reduction in the amount of fat in the meal. However, at a constant temperature of 60 Celsius in the press compartment, no significant difference was found in the amount of residual fat in the meal.

Table 3. Results of analysis of variance of quantitative and qualitative factors affecting oil extracted from the machine.

Parameters	df	Acidity		Peroxide		Moisture of Pomace	
		MS	F	MS	F	MS	F
Rotary velocity	1	0.47	60^{**}	39.42	695.6^{**}	0.66	24.75^{**}
Temperature of compartment	1	1.04	132.7^{**}	24.17	426.5^{**}	3.69	138.4^{**}
Rotary velocity* Temperature of compartment	1	0.16	20.4^{**}	0.31	5.47	0.17	6.37
Repeat	2	0.0015	0.19	0.005	0.088	0.069	2.58
Error	6	0.0078		0.057		0.027	
Total	11						

4. Conclusion

Considering the high demand of the country for oil in various parts of the country, such as agriculture, industry, etc., as well as the country's high potential for irrigated land cultivation, it was necessary to design a device with favorable bombs that could meet this need. The theoretical device has the ability to extract high-efficiency oil and, if it can be mass-produced, is economically feasible. The machine has an effective length of 390 mm extruder, 30 mm gel stroke, 10 mm hollow tooth thickness and 80 mm outer diameter of the gel, and finally an angle of 82.5 °. The function of the device showed that, with increasing temperature, the amount of peroxide and acidity of the oil increased and the quality of the oil decreased. Also, the function of the device showed that, with increasing temperature, the amount of peroxide and acidity of the oil increased and the quality of oil decreased. Also, increasing the temperature reduced the remaining fat in the meal.

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