Performance Evaluation of a Screw Type Oil Expeller for Extraction of Sesame Oil

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Abstract

Sesame, (*Sesamum indicum)* is one of the oldest and important oil seed crop in the world. Mechanized medium scale method has not been previously applied in the oil expelling industry for sesame seed in Sri Lanka. A study was carried out to evaluate the performance of a medium scale screw type oil expeller for extracting sesame oil. The popular screw type machine with 25 mm shaft pitch, 75x315 mm internal barrel and 4 kW three phase motor was used. The development was made in order to increase the oil expelling efficiency in terms of extract bar clearance, speed of the main spiral shaft and outer body closer to the exhaust outlet. The optimum yield of oil was 44% obtained under 0.2 mm and 0.3 mm barrel shaft clearance and the main spiral shaft speed of 75 rpm. The quality of refined oil at maximum oil yield was carried out in terms of saponification value, free fatty acid, specific gravity and color. The saponification value, free fatty acid and specific gravity are 182.33, 3.3.12 % and 0.917 gcm^{-3}, respectively. Color of the sesame oil was closer to the yellow which reveals by the lightness value (L*) of 26 and positive value (b) of 8.27. The capacity and energy consumption per kilograms of refined sesame oil were 39 kg/hr and 0.103 kWh/kg. This study reveals that sesame oil could be obtained using the screw type oil expeller, getting successes for medium scale entrepreneur respect to the traditional Sekku method.

Key words: Sesame oil, Oil extraction, Oil expellers

Introduction

The sesame is one of the world most important and oldest known oil seed crop (Abou- Gharbia *et al.*, 1997). The sesame crop is adapted and cultivated both in the tropic and temperate zones of the world (Biabani and Pakniyat, 2008). It is grown mostly for the oil extraction from the seed which is edible and use for industrial and pharmaceutical purposes. The oil is used in the production of perfumes, skin conditioning agents, moisturizers, hair creams, bath oil, insecticides, paints, vanishes and drugs.

Due to the wider use and importance, sesame has been named as a national high priority crop in Sri Lanka. But sesame oil is highly expensive and not freely available for consumers. One of the main constrain for this is unavailability of efficient oil processing machinery and equipments in the market.

The extraction of sesame oil from the sesame seed is not a completely automated process in Sri Lanka. Even at present, it is done by using the traditional method

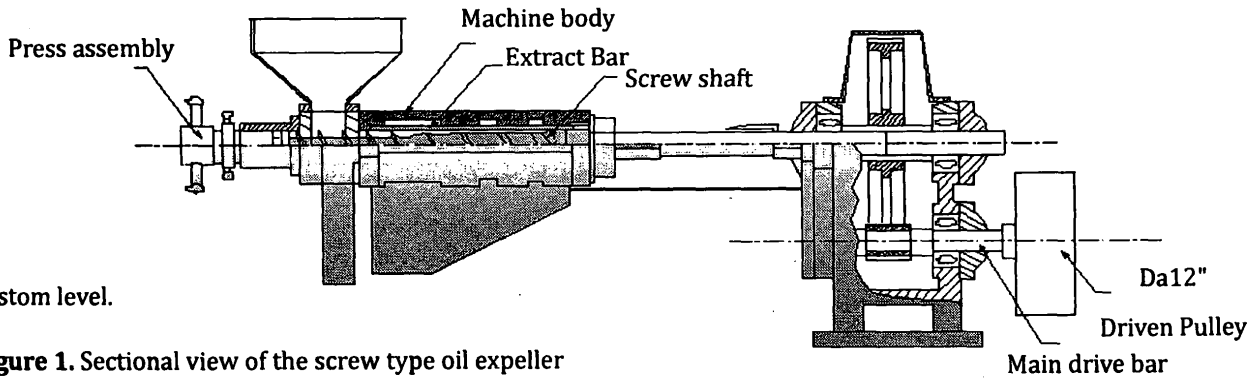

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Figure 1. Sectional view of the screw type oil expeller

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called "Sekku". However, in some instance, screw type coconut extractors are being used for extraction of sesame oil. But, none of the methods has been previously evaluated for their performance. Most of the time, people in different production sectors request a perfect medium scale method for sesame oil extraction. Hence, this study aims at evaluating the most common type of extractor available in the market with an intension to improve its performance to achieve maximum extraction efficiency.

Materials and Methods

At the first stage, extract bars clearance was adjusted from 0.2 mm to 0.3 mm. The rotational speed was set up for four different speeds varying drive pulley diameter 2.5", 3", 4" extras and 6" inbuilt. As the drive shaft diameter is one inch, the smallest pulley diameter compatible with the drive shaft could only be 2.5 inches. The following Table shows how the speed varied using different drive pulleys and their speed ratios. The sample obtained from "Sekku" traditional method was taken into consideration.

A homogeneous bulk sample of sesame seed, MI-2, which is popular in Sri Lanka was used for the experiment. For the each run, three kilogram of sesame was used and a total of four combinations, with two passes through the machine, were used for the experiment. Each combination was replicated three times.

The yields of the oil for different samples were calculated as below.

$$Oy = \frac{O}{s} \; x100 \qquad \text{.....(1)}$$

Where,

Oy = Oil yield

O = Crude oil recovered

S = Mass of the sesame fed

Machine capacity was calculated for each combination.

$$C = \frac{P}{O} \text{ x } 100 \qquad \text{.....(2)}$$

Where,

C = Machine capacity

S = Mass of the sesame fed

T = Time taken for processing

The energy consumption was calculated by considering power consumed by the oil expeller.

$$E = \frac{P}{O} \text{ x } 100 \qquad \text{.....(3)}$$

Where,

E = Energy consumption

P = Electrical power consumed

O = Crude oil recovered

Specific Gravity was calculated using the equations mentioned below.

$$SG = \frac{Ww}{Sv} \times 100 \qquad \text{.....(4)}$$

Where,

SG = Specific Gravity

Ww = Sample weight

Sv = Sample volume

Table 1. Pulleys arrangement for Different speed Combinations

Combination No:	Diameter of Drive pulley/(inch)	Diameter of Driven pulley/(inch)	Speed ratio	Speed of screw shaft/RPM
1	2.5	12	30:1	75
2	3	12	16:1	90
3	4	12	12:1	120
4	6	12	8:1	180
5	"Sekku" method			

According to the AOCS method Saponification value was calculated.

$$SP = \frac{(B-S) \times 28.05}{Gram\ of\ Sample} \quad \ldots\ldots (5)$$

Where,

B - ml of HCl required by Blank.

S - ml of HCl required by Sample.

Percentage of free fatty acid (FFA) oil was calculated according to the AOCS method.

$$FFA\,(\%) = V - B * N_f * 28.2 / W \quad \ldots\ldots (6)$$

Where,

FFA = Free Fatty Acid

V = Volume of the NaOH consumed (ml.)

B = Volume of NaOH consumed during blank titration (ml.)

W = Weight of oil sample (g)

N_f = Normality of NaOH factor

The color of the oil samples was determined using a Chroma meter. Readings of L*a*b values were taken.

Data were analyzed using Analysis of Variance (ANOVA) by Statistical Analysis System.

Results and Discussion

The modification was made including extension of extract bar clearance and overflow outlet. This screw type oil expeller normally uses for coconut oil extraction. The extract bar clearance that was originally 0.1 mm was adjusted to 0.2 mm one side and 0.3 mm other side to suits sesame. Another problem was encountered in pressure releasing outlet on the cylindrical body. Before performing the cake, the mixer came out through this whole was mixed with the extracting oil. This will affect the quality of extracted oil. To overcome this problem the modification was made to direct the pressed mixer to the cake outlet. After the above modification, changing the speed ratios of the machine, the oil expelling trials were conducted as per the speed stated in Table 1. To evaluate the machinery performance, crude oil yield, machine capacity and energy consumption at different speed of screw shaft were calculated.

Raw sesame contained ~53% of oil. As shown in the Table 2, there is no oil extraction happened at the speed of 180 rpm. And it shows the crude oil yield has been increased when the speed of the screw shaft decreased. The maximum oil yield, 44% was obtained at the speed of 75 rpm. This speed is the lowest level of speed that only could be achieved by this machine. There is a significant change in between each and every speed level. Beyond this level, pulley diameter of this selected machine could not be achieved. To get the speed lower than 75 rpm, it is needed to modify the entire screw shaft that was not the objective of this study. The highest machinery capacity 39 kg/hr was also achieved at the speed of 75 rpm and it is the most significant change. The energy consumption during the extraction

Table 2. Machinery and quality parameters at different combinations and the Sekku method

Combination No	Oil yield/ (%) (Crude Oil)	Machine Capacity /(kg/h)	Energy consumption /per 1kg (kWh/kg)	Saponification Value	Colour Value (As per HUE)			Specific gravity/ (gcm^{-3})	Free Fatty Acid Content (%)
					L	a	b		
1	44^{a}	39^{a}	0.103^{c}	182.33^{a}	26.00^{a}	-1.48	8.27	0.917^{a}	3.12^{c}
2	39^{b}	12^{b}	0.333^{b}	181.48^{b}	24.93^{b}	-2.02	11.81	0.907^{b}	3.75^{a}
3	25^{d}	6^{c}	0.667^{a}	176.71^{c}	23.44^{c}	-0.88	10.71	0.815^{c}	3.69^{b}
5	-	-	-	182.02^{a}	26.02^{a}	-1.64	10.28	0.910^{a}	3.20^{c}

*Any two means in the same column followed by different letters differ significantly according to Duncan's multiple range test ($P<0.05$).

per kilogram of oil that is 0.103 kWh/kg is significant at the lowest speed. Considering the percentage of oil yield, machine capacity and energy consumption during expelling; and the best performance is given at the speed of 75 rpm that only could be achieved if the machine is in optimum level. An oil-rich seed such as sesame seed or groundnut yields about 5 percent less oil in a traditional than in a mechanical expeller. (http://www.fao.org visited on 06.03.2013)

The chemical properties of the oil are amongst the most important properties that determines the quality of the oil. Free fatty acid and peroxide values are valuable measures of oil quality. In this study, important parameters; Saponification value and the Free Fatty acid were measured. Saponification value is significant for every three machine combinations and there is insignificance between the 75 rpm speed of the machine and the Sekku method. The saponification value of samples that were recorded for the machine speed of 75 rpm and for the Sekku method were 182.33 and 182.02, respectively. According to the SLSI standards the saponification value for sesame oil is in between 188-193.

Though the Free Fatty Acid value of sesame oil according to the SLSI standards is 2.5%, all the samples in Table 2 exceed the 3.12%. While FFA value is significant among the machine combinations, there is a similar significance value in the 75 rpm speed of the machine and the Sekku method.

According to the Hunter lab L*,a,b color spaces, positive a is red, Negative a is green, Positive b is yellow, Negative b is blue and L value gives the lightness index of the sample. Table 2 shows that all the samples are comply with positive b values which confirmed all four samples are yellow in color. The L value is significant among the machine combinations and it is insignificance in combination 1 and 5. It clearly shows when the machine speed decreases, the lightness of the color increase. There is no significant change in color between the speed of 75 rpm and Sekku method.

The screw type oil expeller which is commonly used in Sri Lanka for extraction of coconut oil in medium and small scale production can be efficiently used for extracting sesame oil. The optimum process parameters for expression of highest yield of crude oil at 44 % and machine capacity 39 kg/hr were obtained under 0.2 mm and 0.3 mm barrel shaft clearance and the main spiral shaft speed of 75 rpm at the rate of energy consumption 0.103 kWh/kg.

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