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RICE BRAN OIL EXTRACTION USING AN EXPELLER MACHINE

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ABSTRACT

A study was carried out to test and evaluate the effect of screw speed, clearance outlet, and steaming process on the extraction efficiency of rice bran oil using a proto type expeller. Four screw speeds of (30, 50, 70, and 90 rpm), four clearance outlets (0.2, 0.4, 0.6 and 0.8 mm) and two different bran conditions (raw and stabilized) were studied and evaluated. Both raw and stabilized bran were steamed for 35 min using a laboratory scale steaming unit. The evaluation system based an: extraction efficiency, machine capacity, and percentage of free fatty acids (FFA) in the extracted oil. The results showed that, steaming process increased the moisture content of raw bran from an initial level of 12.05 % to a final level of 14.52 % w.b, while it increased from an initial level of 6.99 % w.b. to a final level of 12.67 w.b. for the stabilized bran. Moreover, during the expression process, the bran moisture content gradually decreased with the increase of screw speed and the decrease of outlet head clearance. Meanwhile, the percentage of extracted oil decreased with the increase of the expeller screw speed, and outlet head clearance. While, the expeller capacity increased with the increase of screw speed and the outlet head clearance. On the other hands, the steaming process increased the extraction efficiency for both raw and the stabilized bran. While, the steamed stabilized bran showed a slightly lower extraction efficiency in comparison with the steamed raw bran. On the same time, the stabilized steamed bran showed lower percentage of free fatty acids and more storage stability of the extracted oil in comparison with the steamed raw bran.

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INTRODUCTION

In Egypt, the cultivated area of rice is 1.534 million feddan which annually produces about 6.38 million tons (RRTC, 2006). The bran, which is an important by- product, mainly produced during rice milling at amount of 10 % of the weight of rice grain. It is rich in protein 13-16 %, oil 15-22 %, fiber 6.2-14.4 %, ash 8-17.75 %, vitamins, and trace minerals Daniel et al.,(1993). Rice bran constitutes 10 % of the weight of grain and the production of bran during milling process may annually approach 638,000 tons. This amount of bran may produce about130,000 tons of crude oil. Daniel et al., (1993) mentioned that rice bran oil (RBO) is also popular in several countries such as Japan, India, Korea, China and Indonesia as cooking oil. It has been shown that RBO is an excellent cooking and salad oil due to its high smoke point and for its delicate flavor. RBO is known for reducing cholesterol and cardiovascular diseases. Most et al., (2005) investigated the possible cholesterol-lowering properties of rice bran. Rice bran products are frequently consumed in Japan and India, but not readily available in other countries. Earlier findings suggest that consuming rice bran oil can lower cholesterol levels as effectively as oat bran in individuals with moderately high cholesterol. Beneficial results have also been found for substituting rice bran oil for other types of cooking oil. After 10 weeks, total cholesterol had dropped significantly with rice bran oil. Continuous pressing by means of expellers (also known as screw presses) is a widely applied process for the extraction of oil from oilseeds and nuts. It replaces the historical method for the batch wise extraction of oil by mechanical or hydraulic pressing. The expeller consists of a screw (or worm), rotating inside a cylindrical cage (barrel). The material to be pressed is fed between the screw and the barrel and propelled by the rotating screw in a direction parallel to the axis. The configuration of the screw and its shaft is such that the material is progressively compressed as it moves on, towards the discharge end of the cylinder. The compression effect can be achieved, for example, by decreasing the clearance between the screw shaft and the cage (progressive or step-wise increase of the shaft diameter) or by reducing the length of the screw flight in the direction of the axial movement. The gradually increasing pressure releases the oil which flows out of the press through the slots provided on the periphery of the barrel, while the press-cake continues to move in the direction of the shaft, towards a discharge gate installed at the other extremity of the machine (Ferchau, 2000).

Koga (1980) found that other than solvent extraction system there is a method of oil extraction by pressing. This is widely used for oil extraction from rape seed, cotton seed, peanut, coconut, for bran oil extraction also. In the case of rice bran only about half of the contained oil, i.e. 9 to 10 % of bran weight is extracted by pressing. Murai et all (2005) mentioned that the dies employed in the commonly used screw extruders can not stand high pressures (above 400 kg/cm^2), and if the die wall thickness is increased for providing endurance against such high pressures, the die slot is necessarily elongated to increase the surface area of the slot so that a higher pressure is required for accomplishing the desired extrusion. Thus, great difficulties were involved with the use of a common type screw extruder for the pretreatment for extracting crude oil from rice bran. The space between the inner circumferential surface of the die and the outer circumferential surface of the head is preferably within the range of about 0.1 to about 2.0 mm. The properties of the obtained pellets are changed depending on the size of said space. There are known several pretreatment methods for extracting crude oil from rice bran, such as for example a heat treating method involving heating and drying of the rice bran at a temperature above 80 ^oC or a cooking method where heating and drying are performed after adding steam or hot water to the material. An ordinary type of screw extruder can be used for molding of said steamed rice bran because such steamed rice bran, unlike raw bran, is highly viscous and fluid and hence easily pelletizable. However, direct pelletization of raw bran by an extruder requires the treatment to be carried out under a high pressure because of poor viscosity and fluidity (Bor, 1991).

The present study aims to test and evaluate a small and simple expression machine for extraction of oil from rice bran. Engineering parameters affecting the expression efficiency of the tested machine were also studied under different operational conditions.

MATERIAL AND METHODS

Material

Fresh rice bran used for the experiments was taken from a rice variety (Sakha 101) which was harvested from the experimental farm of Rice Mechanization Center and milled immediately after natural drying to a moisture level of about 14 % w. b. using Satake rice mill model (SB 10-D). The produced rice bran was filled in plastic bags and stored temporarily in a freezing room adjusted at a temperature of (-5^{o}C) in order to suppress fungal growth and minimize quality changes.

Equipment:

Steaming unit:

A small-scale steaming unit was designed and fabricated at the workshop of Rice Mechanization Center (R.M.C.), the unit consists of stainless steel water tank of 2 mm thickness and dimensions of 65 cm length, 55 cm width and 45 cm height. The tank was covered by a heavy steel cover and a rubber gasket to prevent steam leakage during the steaming process. A stainless steel screen sheet was rested inside the water tank at 25 cm distance from the bottom to accommodate the bran mats during the steaming process. The water tank and the other parts were carried out over a steel frame with dimensions of (67 x 57 x 100 cm) fabricated from steel angles (25 x 25 mm). The heating process of the water tank was conducted through a butane gas heating source. Figure (1) shows a schematic diagram for the steaming unit.

1-steel cover
2-stainless steel screen
3-water tank
4-butane gas
5-gas valve
6-frame

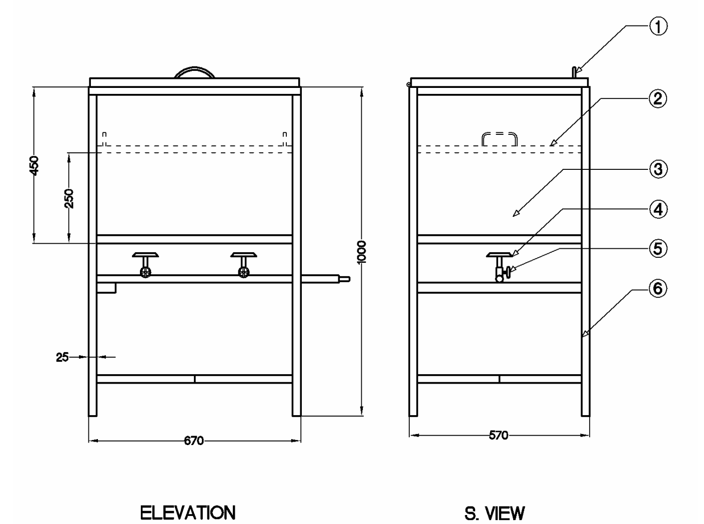

Fig. (1) Schematic diagram of the steaming unit

The conduction heating unit:

An experimental scale rotary conduction heating unit was used to stabilized the rice bran samples at 95 ^oC for 10 min as recommended by Matouk et., al.(2003). Figure (2) presents a schematic drawing of the conduction heating rotary stabilizer.

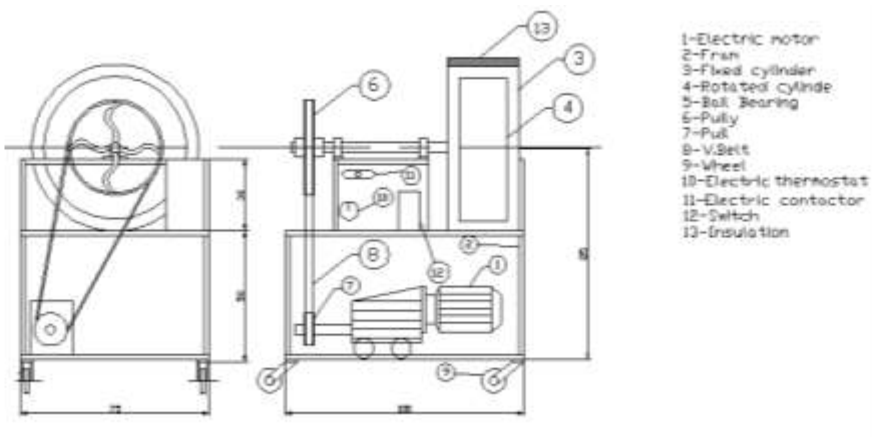

Fig. (2) Schematic drawing of the conduction heating rotary stabilizer

The oil expeller :

A prototype expeller developed by Al-Ashry (1999) for flax oil extraction was used for the experimental work after modification of the barrel design. As shown in Fig. (3), the machine consists of a galvanized iron hopper with a metering device to feed the materials into the feed end of the barrel. The barrel consists of flat steel bars parallel to the worm shaft and the cross section of bars is slightly trapezoidal. The whole set of the bars functions as screen allowing the oil to pass but not the solid. A tapered screw with 56 cm length, 10 cm diameter, 5 cm pitch and a peak height of 1.5 cm was assembled at the center of the barrel. To permit a final adjustment of the extrusion pressure and capacity, an adjustable pressure chook (nozzle) was assembled at the end of the barrel to facilitate the variations in the quantity of raw material and to secure the lowest possible oil content of the cake. The clearance between the worm and choke is controlled by means of a handle lever fitted on a threaded rod and fixed with the warm. By changing the hand lever position the press head clearance can be changed. The power source is an electric motor of 10 hp with rotating speed of 970 rpm. and potential difference 380 V. The power transmit from the source to the machine by means of bullies and V belts. A speed reduction unit was used to reduce the speed from the motor and give the required speed to the press screw (reduction speed ratio is 7:1). The machine parts was fixed on an iron frame manufactured from steel angel (50 x 50cm).

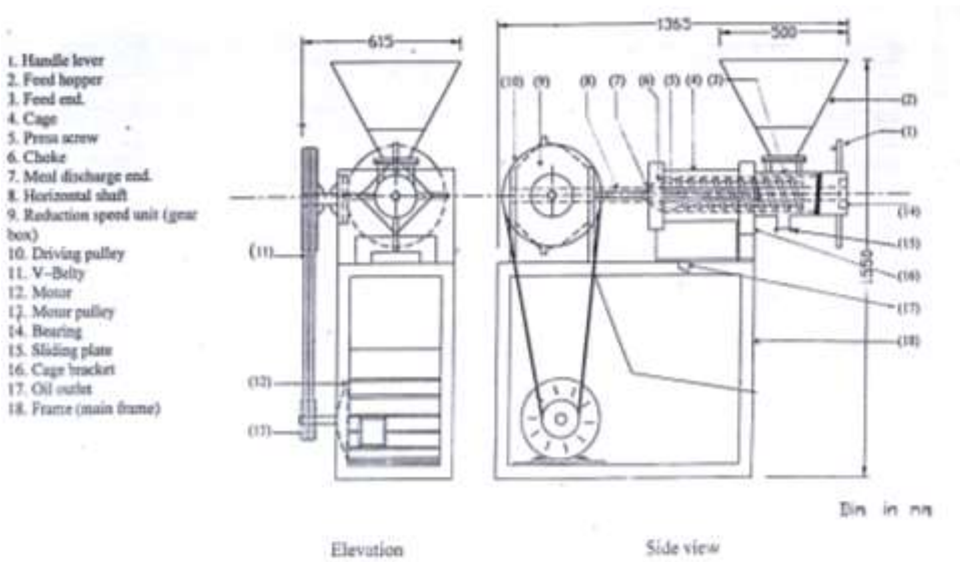

Fig.(3) Schematic diagram of the manufactured expression machine

<u>Machine Modification for rice bran oil extraction:</u>

The barrel (cage) used for extraction of flax oil linseed was modified to fit with rice bran oil extraction. The clearance between the flat steel bars inside the barrel (cage) reduced from (0.125-0.5 mm) to (0.08 to 0.15 mm) forming a screen with tiny slits for allowing the oil to pass through but not bran cake. The bars were also sloped towards the press head clearance by reducing the bars cross section of each bar by 2 mm along the length. The reduced cross section of the bar set raised the compression action of the screw towards the press head clearance. Figure (4) presents cross section for the modified barrel used for rice bran oil extraction.

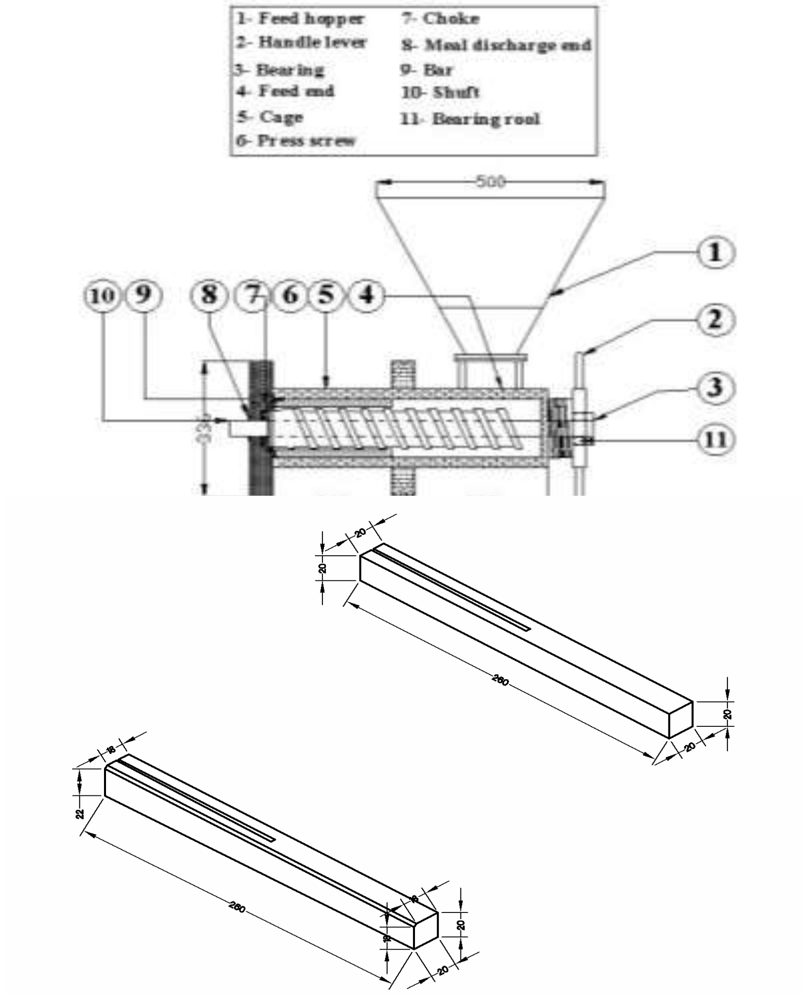

Fig. (4) Cross section of the modified barrel used for bran oil extraction

Experimental treatments

The experimental treatments, included four levels of screw speed (30, 50, 70, and 90 r.p.m.), four levels of the press head clearance (0.2, 0.4, 0.6, and 0.8 mm),and two different types of bran (raw and stabilized bran).

Test procedure and measurements:

Before each experiment, rice bran samples were taken out from the freezing room and left at the ambient temperature until the initial temperature of the rice bran approached a level at or around that of the ambient temperature. The bran samples were divided into two groups, the first group was left without any heat treatment (raw bran) while the second group was subjected to a conduction heating in a rotary heat stabilization unit at heating surface temperature of 95 ^{o}C and exposure time of 10 min as recommended by Matouk et., al. (2003). Both raw and stabilized bran were steamed for 35 min prior to the extraction process. Oil was then extracted from both the raw and stabilized bran using a modified expeller at different levels of screw speed and press head clearance . For each experimental run, the press head clearance between the worm and choke was adjusted by changing the hand lever position of the threaded rod, while the rotating speed of the expeller screw was changed by means of pullies and measured by a digital tachometer model (kIT-201) which give readings in r.p.m. Following this, a samples of bran was placed inside the hoper of the expression machine and the machine was operated. As the liquid phase separated from the bran, the resulted bran cake was mixed and used for determine the remaining percentage of oil, three replicate of 5g dried samples was rolled inside a filtration paper (12.5 Watman) and installed inside a socselett solvent extractor using petroleum-ether at 40-60 ^{o}C for 16 complete circles, then it was allowed to dry in an electric oven at 70 ^{o}C for two hours in order to completely evaporate the remaining solvent from the sample. The obtained samples were again weighed and the percentage of remaining oil was calculated using the following equation:

Remaining oil % = (w_r / w_t) x 100 …………………….. (1)

Where:

w_r = Weight of remained oil, g.

w_t = Weight the bran sample, g.

The extraction efficiency was determined using the following equation;

Extraction efficiency (%) = $O_t – O_r / O_t$ …..……... (2)

Where:

O_r = remained oil, %

O_t = total oil in sample, %

Experimental Measurements:

Moisture content of rice bran

The standard air oven method using five grams sample placed in air oven at 135 ^{o}C for 3 h. used for measuring bran moisture content as recommended by A.O.A.C. (1991).

Free fatty acids percentage (FFA %):

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:

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

$$FFA\ \% = \frac{A.V}{1.99}$$

Where the values 282, and 56.1 refers to the equivalent weight of oleic acid and the potassium hydroxide (KOH) respectively.

Machine capacity:

Time of expression was recorded by means of stop-watch and the machine capacity was calculated using the following formula:

$$\text{Machine capacity (kg/hr)} = \frac{w}{t} * 3.6 \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where:

w = The expressed rice bran weight (g.)

t = Time of expression (sec.)

RESULTS AND DISCUSSION

Bulk temperature and moisture content of the stabilized bran:

After heating process at 95 ^{o}C and exposure time of 10 min using a rotary conduction heating unit. The bran bulk temperature increased with the increasing of exposure time and approached about 9٠.2 ^{o}C at the end of heating period. While the final moisture content of the stabilized bran approached about 6.99 % w.b. in comparison with 12.05% w.b. for the raw bran. On the same time, the (FFA) % approached about 2.36 % immediately after heat treatment for the stabilized bran in comparison with 2.86% for the raw bran. It should be mentioned that the difference in percentage of free fatty acid for the stabilized and the raw bran become obvious after the extraction process and storing the extracted oil for 15 days as mentioned by Koga (1980).

Effect of steaming process screw speed and outlet clearance on bran moisture content

Figure (5) and (6) present the effect of steaming process on bran moisture content. After steaming and prior to the extrusion, the raw bran moisture content increased from an initial level of 12.05 % to final level of 14.52 % w.b, while the stabilized bran moisture content increased from an initial level of 6.99 % w.b. to a final level of 12.67 %w.b. However, after extrusion, the moisture content of the steamed raw bran extruded at the minimum outlet clearance of 0.2 mm decreased from 14.52 % w.b. to 4.86, 4.99, 5.16, and 5.33 at screw speeds of 30, 50, 70, and 90 r.p.m respectively. While it was decreased from 12.67% to 4.76, 4.87, 5.06 and 5.06 % for the steamed stabilized bran. However, at the maximum outlet clearance of 0.8 mm, the steamed raw bran moisture content decreased from an initial level of 14.52 % w.b. to final levels of 5.23, 5.46, 5.87, and 6.67 respectively. While the moisture content of the steamed stabilized bran decreased from an initial level of 12.05 % w.b. to final levels of 6.00, 6.17, 6.72 and 6.98 % w.b. respectively.

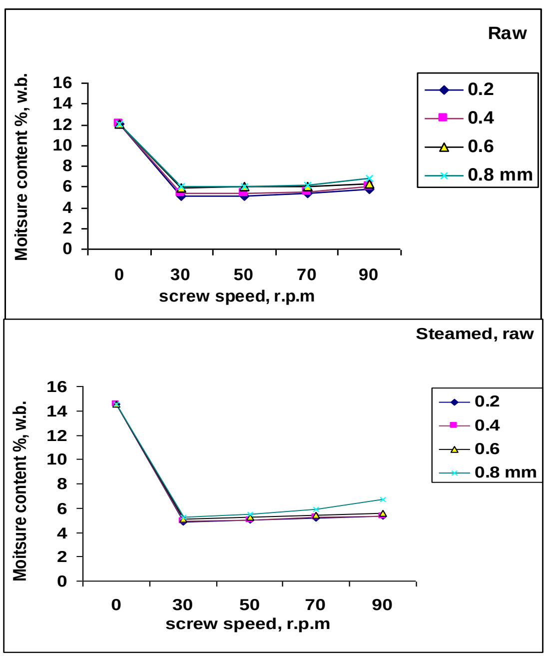

Fig. (5) Effect of screw speed and clearance outlet on moisture content of the raw bran

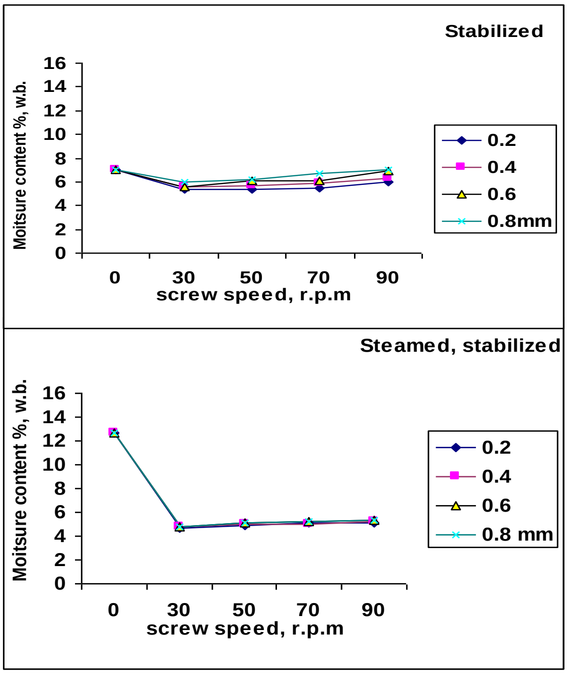

Fig. (6) Effect of screw speed and clearance outlet on moisture content of the stabilized bran

Effect of steaming process, screw speed and outlet clearance on extraction efficiency of oil :

Figures (7) and (8) present the effect of steaming process, screw speed and outlet clearance on the extraction efficiency of raw and stabilized bran. As shown in the figure, the extraction efficiency increased with the steaming process, while it was decreased with the increase of screw speed and the outlet head clearance. As shown in the figure, at outlet clearance of 0.2 mm and screw speeds of 30, 50, 70, and 90 r.p.m the extraction efficiency of the raw bran increased by the steaming process from (18.96 to 40.19%), (17.88 to 38.94%), (16.33 to 36.88%), and (14.18 to 34.35 %) respectively. While, it was increased from (14.86 to 23.94%), (13.86 to 22.54%), (12.66 to 20.66%) and (11.09 to 18.35%) respectively for the stabilized bran. Meanwhile, at the maximum outlet head clearance of 0.8 mm and screw speeds of 30, 50, 70, and 90 rpm the extraction efficiency of the raw bran increased by the steaming process from (11.20 to 27.32%), (10.03 to 25.77%), (8.55 to 23.20%), and (6.35 to 19.84 %) respectively. While, it was increased from (8.76 to 14.46%), (7.98 to 13.86%), (7.06 to 11.78%) and (5.98 to 9.67 %) for the stabilized bran. Similar trends were observed at outlet clearances of 0.4 and 0.6 mm. The observed increase in the extraction efficiency of the bran oil with the steaming process may be due to the fact that, wet heat treatment freeing the lipids from other components in bran cells and facilitate the oil extraction as mentioned by (Bor, 1991). While, the reduction of the extraction efficiency with the stabilization process may be due to the lower levels of moisture content in the stabilized bran in comparison with the raw bran which causes lower rate of freeing the lipids from other components. This means that, the steaming process prior to extraction process is recommended for increasing the extraction efficiency for both raw and stabilized brans.

To relate the changes in the extraction efficiency (E_f) with the outlet clearance (C), and screw speed (D). A regression analysis was employed. A generalized relationships were obtained for both types of bran (raw and stabilized bran) as presented in table (1).

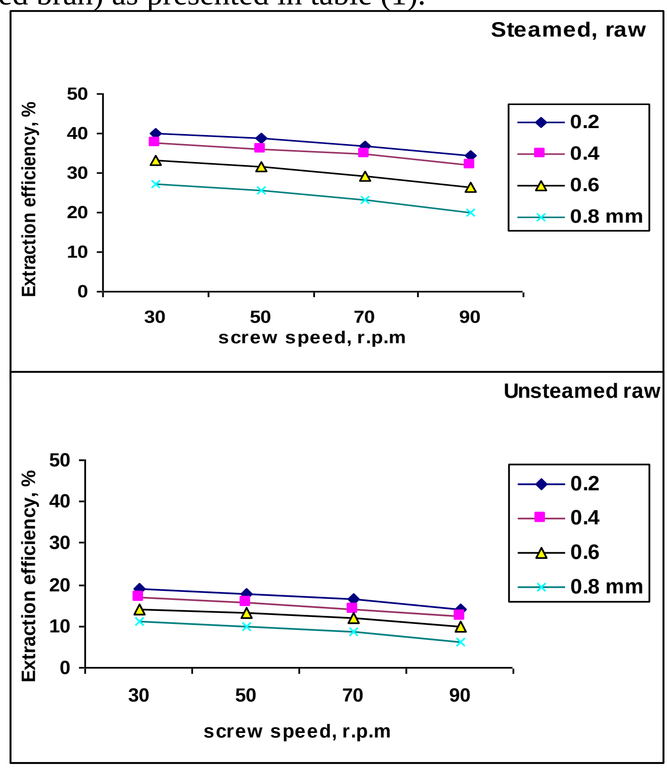

Fig. (7) Effect of steaming process, screw speed and outlet clearance on extraction efficiency of the unsteamed and steamed raw bran.

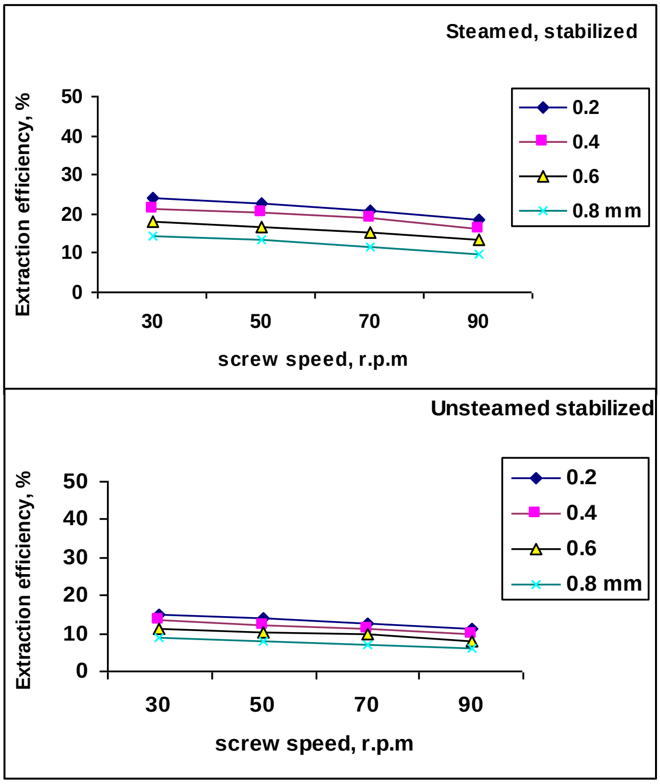

Fig.(8) Effect of steaming process, screw speed and outlet clearance on extraction efficiency of the unsteamed and steamed stabilized bran.

Table (1): Equations relating the outlet clearance, and screw speed with the extraction efficiency of rice bran.

Type of bran	Regression equation	S. E.	R^2
Steamed raw bran	E_f **= 49.540 – 22.851 C - 0.1070 D**	1.097	0.970
Steamed Stabilized bran	E_f **= 29.793 – 15.252 C - 0.0830 D**	0.505	0.986
Unsteamed raw bran	E_f **= 24.111 – 12.920 C - 0.0739 D**	0.425	0.987
Unsteamed stabilized bran	E_f **= 18.482 – 9.3760 C – 0.054 D**	0.377	0.981

<u>Effect of screw speed and outlet clearance on machine capacity</u>

Increasing the screw speed and the outlet head clearance tended to increase the machine capacity during the expression process. As shown in figure (9) the machine feeding capacity of the steamed raw bran extruded at outlet clearance of 0.2 mm. increased from (38.88, to 47.98 kg/h) as the screw speed increased from 30 to 90 rpm, while it was increased from (40.16 to 51.24 kg/h) for the steamed stabilized bran. Meanwhile, at the maximum outlet head clearance of 0.8 mm. the machine capacity increased from (48.11 to 60.16 kg/h) for the steamed raw bran in comparison with (50.08 to 60.18 kg/h) for the steamed stabilized bran. Also fig.(10) shows that, the machine feeding capacity of the raw bran extruded at outlet clearance of 0.2 mm. increased from (41.55, to 50.86 kg/h) as the screw speed increased from 30 to 90 rpm respectively. While, it was increased from (43.65 to 52.67 kg/h) for the stabilized bran. Meanwhile, at the maximum outlet head clearance of 0.8 mm. the machine capacity increased from (51.48 to 61.25 kg/h) for the raw bran in comparison with (53.46 to 63.38 kg/h) for the stabilized bran.

To relate the changes in Machine capacity (M_c) with the outlet clearance (C), and screw speed (D). A regression analysis was employed. A generalized relationships were obtained for both types of bran (raw and stabilized steamed bran) as presented in table (2).

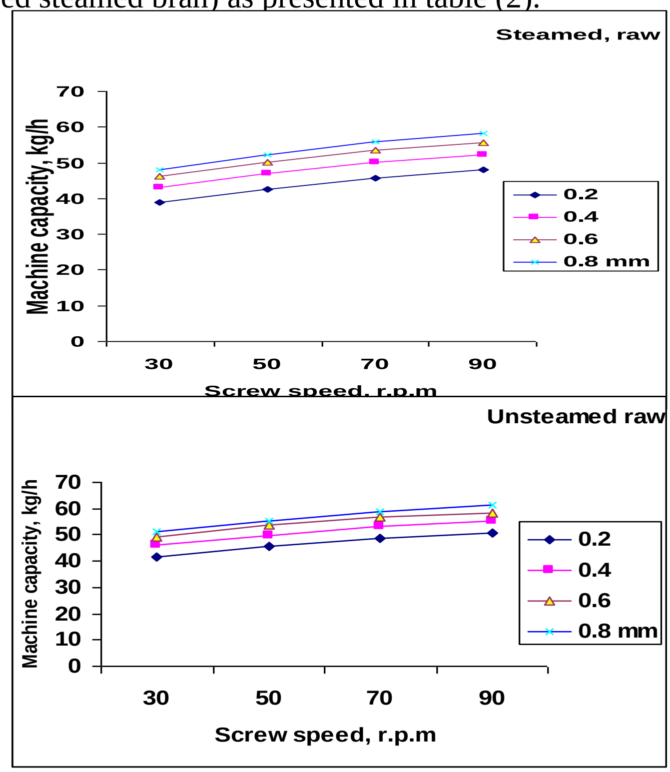

Fig. (9) Effect of steaming process, screw speed and outlet clearance on machine capacity of the raw bran

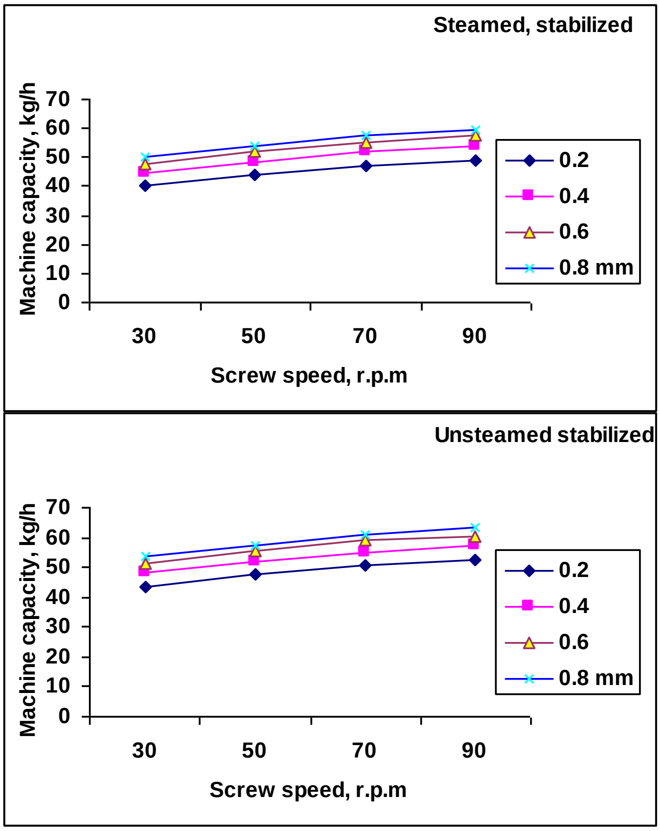

Fig. (10) Effect of steaming process, screw speed and outlet clearance on machine capacity of the stabilized bran

Table (2) Equations relating the outlet clearance, and screw speed with the machine capacity.

Type of bran	Regression equation	S. E.	R^2
Steamed raw bran	M_c **= 31.548 + 16.383 C + 0.158 D**	0.793	0.980
Steamed Stabilized bran	M_c **= 33.008 + 16.730 C + 0.156 D**	0.894	0.975
Unsteamed raw bran	M_c **= 34.400 + 16.872 C + 0.157 D**	0.846	0.979
Unsteamed stabilized bran	M_c **= 36.311 + 17.170 C + 0.155 D**	0.857	0.978

FFA % of the extracted oil:

Figures (11) and (12) present the effect of stabilization process on the percentage of free fatty acids in the extracted oil under different screw speeds and outlet clearances. At the minimum clearance outlet of 0.2 mm and screw speeds of 30, 50, 70, and 90 r.p.m. The (FFA) % of the extracted oil increased from an initial levels of (2.86%) to final levels of

3.96, 3.96, 4.15 and 4.15% respectively for the steamed raw bran, While it was increased from (2.86%) to 3.26, 3.33, 3.33 and 3.33 % respectively for the unsteamed samples. However, the percentages of free fatty acids of the steamed stabilized bran increased from (2.36%) to 3.36, 3.39, 3.41, and 3.47% respectively. While it was increased from (2.36%) to 2.86, 3.05, 3.05 and 3.13% for the unsteamed stabilized bran. On the other hands, with increasing the outlet head clearance to 0.8 mm, and screw speeds of 30, 50, 70, and 90 r.p.m. the percentage of free fatty acids of the raw bran increased from (2.86%) to 4.06, 4.06, 4.26 and 4.26% for the steamed samples, While it was increased from (2.86) to 3.36, 3.46, 3.46 and 3.56 % for the unsteamed samples. However, the percentages of free fatty acids of the steamed stabilized bran increased from (2.36%) to 3.47, 3.47, 3.49, and 3.53% respectively for the steamed samples. and it was increased from 2.36% to 2.97, 3.13, 3.26 and (3.26%) for the unsteamed samples.

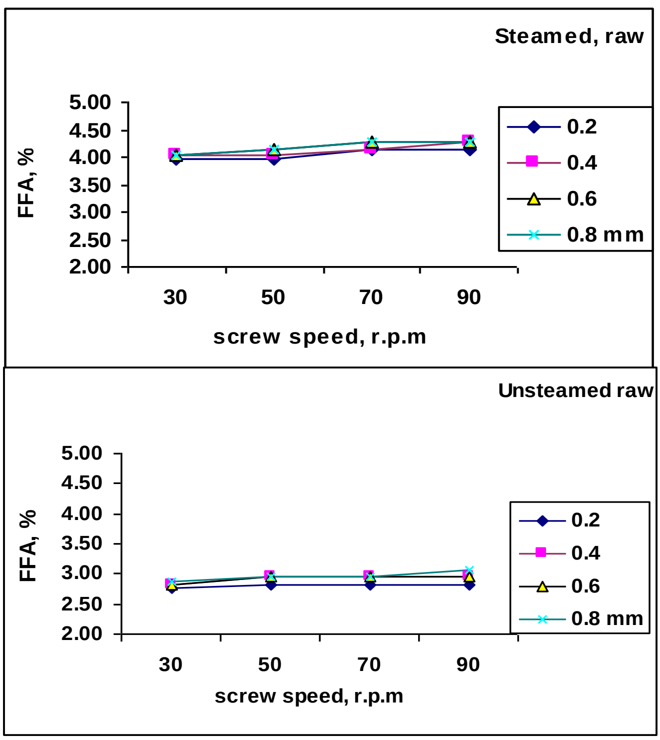

Figure (11) Effect of steaming process, screw speed and outlet clearance on FFA % of the raw bran.

To relate the changes in Free fatty acids % (FFA %) with the outlet clearance (C), and screw speed (D). A regression analysis was employed, a generalized relationships were obtained for both types of bran (raw and stabilized bran) as presented in table (3).

Table (3): Equations relating the outlet clearance, and screw speed with the Free fatty acids %.

Type of bran	Regression equation	S. E.	R^2
Steamed raw bran	**FFA % = 3.785 + 0.192 C + 0.004 D**	0.048	0.845
Steamed Stabilized bran	**FFA % = 3.338 + 0.061 C + 0.001 D**	0.035	0.454
Unsteamed raw bran	**FFA % = 3.153 + 0.256 C + 0.002 D**	0.062	0.611
Unsteamed stabilized bran	**FFA % = 2.698 + 0.200 C + 0.005 D**	0.051	0.873

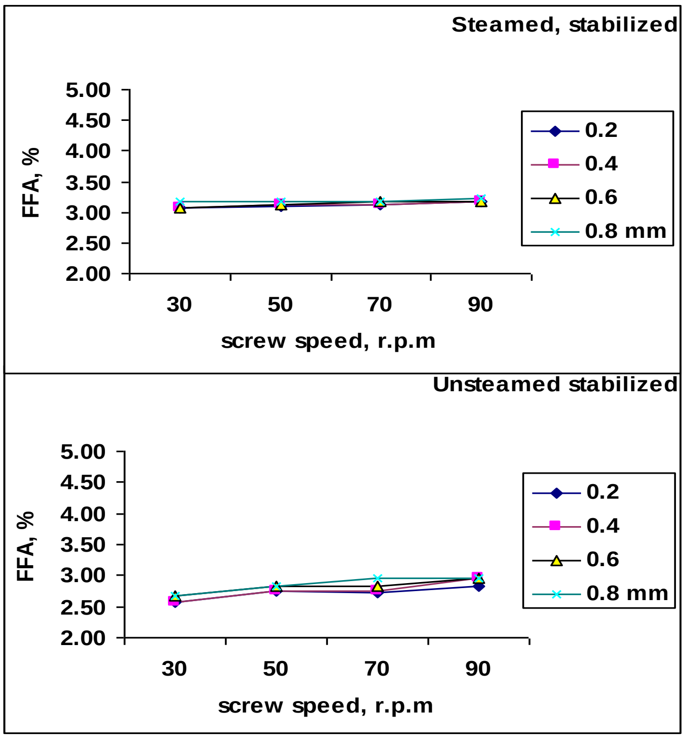

Figure (12) Effect of steaming process, screw speed and outlet clearance on FFA % of the stabilized bran.

CONCLUSIONS

1- The bran moisture content increased with the steaming process, while it was gradually decreased with the increase of screw speed and the decrease of outlet head clearance.

2- For both raw and stabilized bran, the extraction efficiency increased for the steamed bran in comparison with the un-steamed bran.
3- The extraction efficiency increased with the decrease of screw speed, and the outlet head clearance while, the machine capacity decreased.
4- Heat stabilization of the bran samples prior to steaming process slightly decreased the extraction efficiency of the stabilized bran in comparison with the raw bran.
5- The percentage of free fatty acids (FFA%) in the oil extracted from stabilized bran was greatly lower than that of raw bran, which may keep the oil more stable during the storage process.

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الملخص العربى

استخلاص زيت رجيع الأرز باستخدام وحدة كبس مستمر

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بالرغم من أن الاستخلاص بالمذيبات تعتبر من إحدى الطرق المستخدمة لاستخلاص الزيت من رجيع الأرز إلا أن ارتفاع تكاليف أقامه وحدات منها بالإضافة إلى التقنية المعقدة والتى تسبب بعض المشاكل مع رجيع الأرز مثل انسداد خطوط الإنتاج نتيجة لذرات الرجيع الدقيقة و التي يصعب فصلها من مخلوط الزيت والمذيب (الميسيلا) يستلزم البحث لايجاد طرق جديدة لاستخلاص الزيت من رجيع الأرز. لذلك أجريت تلك الدراسة بهدف إيجاد طرق أخرى لاستخلاص زيت رجيع الأرز تمثلت فى وحدة للكبس المستمر روعي فيها أن تكون صغيرة الحجم منخفضة التكاليف تناسب معاصر الزيت الصغيرة والمتوسطة مع دراسة انسب العوامل التى تؤدى الى الحصول على أعلى كفاءة لاستخلاص الزيت باستخدام تلك الوحدة.

وقد أمكن تلخيص النتائج المتحصل عليها فيما يلى :

١- ارتفع المحتوى الرطوبى للرجيع أثناء عملية التبخير بينما انخفض أثناء عملية الكبس لكلا من الرجيع الخام والرجيع المثبت حراريا وانخفض الفقد فى المحتوى الرطوبى بزيادة كلا من الخلوص وسرعة البريمة.

٢- انخفضت نسبة الزيت المتبقى فى كسب الرجيع بانخفاض كلا من سرعة دوران البريمة, وخلوص فتحة الخروج مما يعنى زيادة كفاءة الاستخلاص لكلا من الرجيع الخام و الرجيع المثبت حراريا حيث تراوحت تلك الكفاءة بين (٤٠,١٩ الى ١٩,٨٤ %) للرجيع الخام وبين (٢٣,٩٤ الى٩,٦٧ %) للرجيع المثبت حراريا.

٣- زادت سعة الآلة بزيادة كلا من سرعة دوران البريمة وخلوص فتحة الخروج لكلا من الرجيع الخام و الرجيع المثبت حراريا.

٤- كانت نسبة الزيت المستخلص للرجيع المثبت حراريا اقل من نسبة الزيت المستخلص للرجيع الخام فى حين كانت نسبة نسبة الأحماض الدهنية الحرة (FFA) للزيت المستخلص من الرجيع المثبت اقل منها فى الرجيع الخام مما يؤدى الى ثبات الزيت المستخلص أثناء عملية التخزين.

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