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Maximize the Utilization of some Residuals Food Manufacture

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ABSTRACT

The current study was carried out to test and evaluate the possibility of maximizing the utilization of some residuals food manufacture (orange peel). A cutting and pressing machine was designed and fabricating for conducting the experimental work. The developed machine was tested and evaluated under the following parameters; three speeds of cutting for serrated knives of 1000, 1200and 1400 rpm (9.42, 11.304 and 13.188 m/s) and three knives number of 6, 8 and 10, at constant screw speed of 60 rpm. The measurements taken into consideration to investigate the performance of the developed machine included productivity (kg/h), percentages of cutting length (%), energy requirements (kW.h/Mg) , operating cost (EGP/Mg), and percentage contents of oil and pectin. The obtained results indicated that the highest value of machine productivity for orange peel residues was 120.98 kg/h. The value of energy requirements and operating cost were 73.50 kW.h/Mg and 233.75 EGP/Mg respectively. The highest percentage of oil were 4.38 % and 4.24% ml /100g gross weight and pectin were 40.89 and 36.19% g/100g which obtained at cutting length for orange peel residuals < 0.5 and 0.5 - 1cm. These results were obtained under the operating conditions of; knives speed was 1400 rpm (13.188 m/s) and 10 cutting knives at constant screw speed of 60 rpm.

***Keywords*:** Orange peel; Knives speed; Productivity; Percentage of oil and pectin.

INTRODUCTION

The agricultural and food processing residues are considered one of the most problems facing the farming and the environmental pollution. The suitable solution to solve this problem is to recycle these residues to be converted into useful products such as animal forage, compost and artificial materials (Ismail, 2001 and Ismail *et al.*, 2017). To achieve this aim, cutting, pressing and drying of the residues is the best solution for solving these environmental problems, where the final production of these processes can be introduced in producing various products such as compost, forage and many food industry (Abou-Elmagd, *et al.*, 2001 and Ismail *et al.*, 2011).

Orange is one of the most common fruits with a lot of nutritional values; it is most consumed for its dietary benefits. After extraction of juice, the orange peels are treated as residuals and lead to environmental pollution due to improper disposal can be used for the extraction of citrus oil and pectin which can be used many applications including food flavouring and cosmetics.

Egypt produces orange fruits about 72.3% of the total production of citrus fruits with approximately 3.42 million tons (USDA, 2022).

Orange peels are the major source of commercial pectin. Pectin is a polysaccharide compound present in the rind of citrus fruits. Pectin is used in different industries such as pharmaceuticals and food processing (Abdel Hamid *et al.*, 2022).

Peeled or juiced fruits for various uses have increased environmental risk and huge economic losses from the leftovers that could be used as feedstuffs (BPF) as an alternative feed for ruminants. This means that 50–60% of processed fruit is converted into citrus peel waste (Erdem *et al.*, 2019).

World orange production is estimated at 60 million tons per annual, while the annual production of orange peel waste is 32 million tons (Igolima *et al.*, 2023).

El-Haddad (2010) developed the local threshing machine for small holding to suit chopping and shredding crops residues. He found that the percentage of small cutting lengths were increased by increasing cylinder speed and feed rates and decreased by increasing the moisture contents. The maximum of the percentage of small cutting lengths were (21% ≥0.5 cm, 50% from 0.5 to 1 cm, 12% from 1 to 2 cm and 17% from 2 to 3 cm), at cylinder speed of 9.11 m/s (600 rpm) and moisture content of 22.3% in straw and feed rate of 8 kg/min.

Imbabi (2003) tested the performance of the stubble shredder in the process of cutting corn stalks. The obtained results showed that the use of a serrated edge knife significantly decreased the cutting energy requirements by 8-15% and increased the cut length of less than 5 cm length by about 90%, and it also increased the service life by a factor of 1.18 – 2.25, as compared to the smooth edge knives.

Ismail *et al* (2009) said that developed a chopping machine for agricultural residue (a case study on grape waste). They use two different shapes of cutting knives (straight edged and serrated edge). The maximum value of cutting efficiency and capacity resulted with a serrated-edge. The optimum performance of the developed cutter was obtained at feeding mechanism speed of 0.28 m/s and cutter head speed of 1.88 m/s by using serrated-edge cutting knives.

Tavakoli *et al* 2009) said that they studied the effects of number of blades on each flange on the power requirement for the size reduction of wheat straw. They reported that the power requirement decreased by increasing the number of blades from 4 to 8 in each flange. The power requirement for the size reduction of wheat straw ranged between 0.985 to 5.377 kW and the average power requirement was 2.763 kW.

Tested and evaluated the expelling machine for extracting the wheat germ oil at five screw speeds (25, 35, 45, 55, and 65 rpm) and four levels of press head clearance (0.5,

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1, 1.5, and 2 mm) to determine the best machine capacity, percentage of oil recovery, percentage of residual oil, and specific energy consumption. The results showed that the maximum machine capacity was 39 kg/h of raw material at 2mm outlet clearances and 65 rpm of screw speed. The best operating pressing conditions for oil recovery were 45.7% at 25 rpm screw speed and 0.5 mm press head clearance, when the required specific energy was 0.0232 kWh/kg El-Nono and Abdel-Gawad (2015).

Kaddour (2003) noticed that the cost was decreased by increasing screw speed from 1.01 to 1.41 and up to 1.81 m/s by 2.10 and 3.11% at milling fineness degree of 2mm and number of holes of 22 using effective hole of 25.5 mm. He added that increasing of costs per mass unit by increasing screw speed from 1.81 to 2.22 m/s. could be due to the sharp decrease in production rate and high increasing in consumed power.

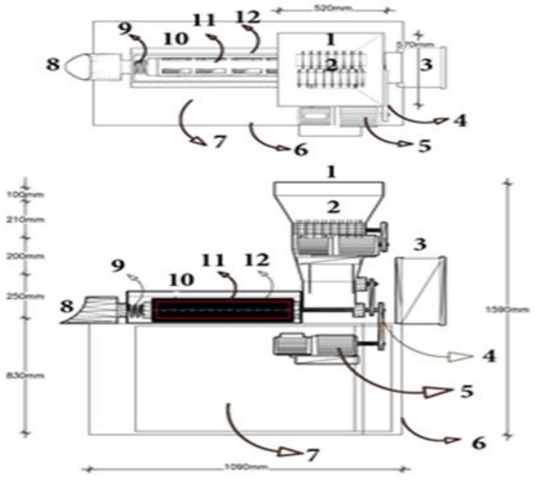
The current study aims to design, evaluate and test a cutting and pressing machine. The machine was assigned as performance unit for orange peel residual to produce oil and pectin substances.

MATERIALS AND METHODS

The main experiments were carried out through the years 2022 and 2023 at Workshop of Agricultural Engineering and Biosystem Department-Faculty of Agriculture-Minoufiya University, Minoufiya-Governorate–Egypt. Asmall scale (prototype) combined machine was designed and manufactured in local workshop for cutting and pressing orange peel in order to produce pectin and oil from orange peel residuals.

The developed cutting-pressing machine:

The developed machine was consists mainly of main hopper, cutting knives, Electrical panel, transmission system, main electric motor, frame, Juice tank, cake outlet, spring, screen cover , screw shaft and press vessel as shown in Fig. (1) and Fig (2).The schematic diagram of the procedure used for the components of the developed cutting-pressing machine could be described as follows:



No.	1	2	3	4	5	6
Part name	**Orange peel hopper**	**Cutting knives**	**Electrical panel**	**Transmission system**	**Main electric motor**	**Frame**
No.	**7**	**8**	**9**	**10**	**11**	**12**
Part name	**Juice tank**	**Cake outlet**	**Spring**	**Screen cover**	**Screw shaft**	**Press vessel**

Fig. 1. Schematic diagram of cutting - pressing machine. Source: Author's own illustration.

Fig. 2. Cutting - pressing machine

Orange peel residuals:

Samples of orange peels were taken immediately from the residues of the industrial juice extraction line in the Egyptian Canning Company Fig. (3) , The fresh peel samples were mixed in uniformity homogenate pattern, sealed in plastic bags and stored in refrigerator at 5ºC to prevent fungal growth. Before any experimental run, the peel samples were taken out of the refrigerator and kept in the laboratory to attain room temperature.

Fig. 3. Orange peel residuals.

The orange peels hopper:

The feed hopper is the part where the batch is prepared before shredding. It was made of T-304 stainless steel (3 mm thick). It has main dimensions of length of 570 mm, a width of 520 mm, and a height of 310 mm. The maximum capacity of the feeding hopper is about 15 kg.

The cutting knives:

The operation theory of the cutting unit is based on the cutting force through two sets of knives, the two sets of knives participating for the cutting and moving process. The first set of cutting knives (high speed knives) takes its power from 1 HP (0.7457 kW) motor and the other set of cutting knives (low speed knives) takes its power from 10 HP (7.457 kW) motor as shown in Fig. (4) and Table (1) as shows the specifications of cutting knives. During the rotating of the cutting knives, the cutting edges of the knives penetrate the orange peel, overcome its strengths and thus cut them off. During this process, various deformations occur on the material.

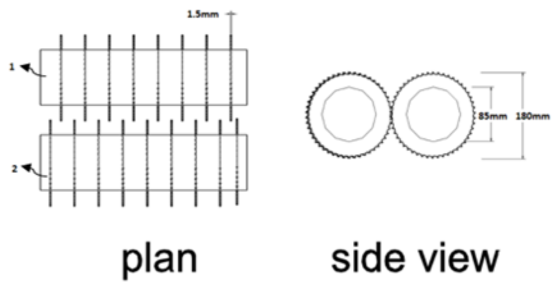


Fig. 4. Schematic diagram of the cutting knives

Table 1. Technical specifications of the cutting knives.

Items	Values
Material	Steel
Origin of manufacture	China
Output Diameter	180mm
Input Diameter	85mm
Thickness	1.5mm
Shape	Serrated
Number of teeth	80
Angle of edge	30º
No. of Knives	6, 8 and 10

The transmission system:

The power is transmitted from the power source to the other moving parts by means of a chain and gears with different speed ratios. The ratio between the gears is easily changed to transfer the motor. Two gears were installed on the screw shaft and the main motor was connected through a chain. The power transmission was chosen based on the required speed ratio.

The power source:

An electric motors and gearboxes were assigned to promote the speed change of the machine parts. The cutting and pressing machine was driven by two electric motors of (0.7457 and 7.457kW), (1.0 and 10 HP). The first motor of 1 HP was used for rotating the knives at speeds of 1000, 1200 and 1400 rpm and the second motor of 10 HP motor was used for rotating the screw at the speeds of 60 rpm.

The machine frame:

The frame consists of two parts. The first part is made of stainless steel. It is a rectangular base with dimensions of 75 x 109 cm and a height of 83 cm. It holds the motor and the tank. The second part is an extension of the first part made of stainless steel, which is carrying the screw and the feeding hopper. The height of this part is 76 cm, the length is 93 cm, and the total height of the machine is 159 cm from the ground. The machine frame was equipped with wheels for easy transportation and movement.

Cake outlet:

The cake outlet is located at the end of the press vessel. A spring was used at the end of an open circular channel for the cake outlet, which was made of special heat-treated steel to withstand the pressure.

Screen cover:

The pressed orange peels were supplied through a single piece stainless steel wedge wire screen, with slots of 3*3 mm. It has stationary resistor teeth to prevent co-rotation.

The Screw shaft:

A tapered root type screw was designed to provide a rate of pressure increase depending on the taper angle of the shaft compared to a straight screw shaft. The screw shaft had a length of 600 mm and an outer diameter of 120 mm to allow space between the shaft and the barrel. The root diameter was threaded through the screw with a thread depth decreasing continuously along the screw shaft from 16 mm to 7.5 mm. In such a situation, the frictional force between the screw shaft and the bowl increases, and the required rotating torque becomes higher.

The press vessel:

The bowl is the cage of screw shaft, which is supposed to rotate the pressed cake, let the juice flow out of the bowl to prevent any blockage. So there are important points while designing the bowl mainly on two areas which are holes and grooves for draining juice inside the tank. There is a cover at the top of the bowl made of stainless steel with holes of (3 * 3 mm). The bowl material was selected from stainless steelT-304 for ease of fabrication and rust prevention. The bowl length, inner diameter, and outer diameter are 800, 152, and 169 mm, respectively. A square whole (200 x 200 mm) for mounting the hopper was installed at a distance of 800 mm at the beginning of the bowl. Longitudinal holes draining juice with a length of 40 mm were drilled in the lower central region of the bowl.

Instruments

Electric balance:

The initial and final mass and mass changes during the drying experiments of each sample were measured in the laboratory by electric balance with accuracy of ±0.01g.

Clamp meter:

Super clamp meter model 600v~Ac 50 Hz. (Japanese manufacture) with an accuracy (± 0.5 Ampere) was used to measure the current and voltage respectively.

Vernier caliper

Vernier tweezers (150 x 0.05 mm) was used for measurement of dimensions of orange peels pieces after cutting and pressing.

Drying oven

To determine the moisture content of orange peel residual at different stages of machine processing.

Experimental treatments

The practical experiments were carried out to optimize some operating parameters affecting the performance of the cutting and pressing machine, as follows:

1. Three knives speeds of 1000, 1200 and 1400 rpm corresponding to drum peripheral speeds were 9.42, 11.304 and 13.188 m/s., respectively.
2. Three knives number of 6, 8 and 10.

Evaluation of Cutting and pressing Machine Performance

The constructed machine was tested to study some parameters affected on the cutting operation as follows:

1- Percentage and distribution of cutting lengths, cm.
2- Machine productivity, Mg/h.
3- Energy requirements, kW.h/Mg.
4- Operating cost, EGP./Mg.
5- Product material.
A - Percentage of oil.
B - Percentage of pectin.

1- Cutting lengths percentage

The cutting lengths were evaluated by taking a sample of 1.0 kg of product of cutting orange peels into the laboratory and separated the sample into four categories (< 0.5, 0.5-1, 1-3 and > 3 cm). Each cutting length in the sample was weighed and calculated as a percentage of the total mass. The categories cutting lengths percentage was calculated by the following formula:

$$\textit{Cutting length percentage} = \frac{\textit{mass of the category}}{\textit{total mass of total output sample}} \times 100 \quad (1)$$

2- Machine productivity.

Orange peels of 1.0 kg were fed into the chopper for each treatment and the cutting time in minutes was recorded. The machine productivity was calculated as following (Barakt 2016):

$$P = \left(\frac{W}{T}\right) \times 60 \qquad (2)$$

Where:

P: productivity, kg/h.
W: mass of the sample, kg
T: cutting time, min.

3- Energy requirements.

The required power (kW**)** for different processing steps of the machine was measured by using clamp meter and the energy requirements (kW.h/Mg) could be calculated as follows:

$$\textit{Energy Requirements} = \frac{\textit{Required Power,kW}}{\textit{Machine Productivity,Mg/h}} \quad \textbf{(3)}$$

4- Operating cost

The operating cost (EGP /Mg) was calculated according to the price of materials in year 2022 by the following formula:

$$\textit{Operating Cost} = \frac{\textit{Machine cost } (\frac{EGP}{h})}{\textit{Machine Productivity,Mg/h}} \quad \textbf{(4)}$$

Machine Cost

The cost analysis was performed considering the conventional method of estimating both fixed and variable cost (Shepley and Schantz, 1984).

Total costs =fixed cost +variable cost (EGP /h) (5)

The fixed costs include:

Depreciation, interest on investment, taxes, insurance.

The variable costs include:

Labors, electricity, repair and maintenance.

5- Product material

A - Percentages of oil

$$\mathbf{EOY} = \frac{(\mathbf{Wf} - \mathbf{We})}{\mathbf{Ws}} \times \mathbf{100} \qquad (6)$$

Where:

EOY= essential oil yield (%).
Ws = mass of sample (g).
We = mass of empty flask (g).
Wf = mass of flask and extracted oil (g).
(Fakayode and Abobi 2018).

B - Percentages of pectin

Pectin extraction from orange peels was done in two stages. Oil was first extracted from the orange peel samples after which pectin was isolated with acid hydrolysis technique as suggested by (Pandharipande and Makode 2012).

$$\boldsymbol{DPY} = \frac{\boldsymbol{Wd}}{\boldsymbol{Wp}} \times \mathbf{100} \qquad (7)$$

Where:

DPY= dried pectin yield (%).
Wd = mass of dried pectin obtained (g).
Wp = initial mass of orange peel powder used for extraction (g).

The statistical analyzing

Statistical analyzing and mathematical model, a factorial experiment according to randomized complete blocks design of samples layout design was taken. Then the multiple regression analysis of the cutting length categories, the machine productivity, the energy requirements and the percentage of oil yield used by Excel version 10 to produce the mathematical model.

RESULTS AND DISCUSSION

Cutting-pressing process was evaluated separately by studying the percentage of different cutting lengths, cutting efficiency, machine productivity, energy requirements , operating cost and product material as following:

1. Categories and percentage of cutting lengths:

Fig. (5) illustrate the percentages of cutting length at different knives speed and knives number.

Effect of knives speed:

The results in Fig.(5) show the relationship between the percentage of cutting length and categories of cutting length (< 0.5, 0.5-1, 1-3 and > 3 cm) at different speeds of both knives. It's noticed that increasing knives speed from 1000 to 1400 rpm (9.42 to 13.188 m/s) led to increase the percentage of cutting lengths at categories < 0.5 and 0.5-1 cm and decreasing the percentage of cutting length at categories 1-3 and > 3 cm. As example, it was increased the length parentage of category 0.5 -1cm from 32.94 to 39.69%. On the other side the data in the Fig. (4) showed that increasing knives speed from 1000 to 1400 rpm (9.42 to 13.188 m/s) led to increase the percentage of cutting length at category < 0.5 cm from 49.56 to 60.24%. On the other hand, decreased both the percentage of cutting length at categories 1-3 and > 3 cm were decreased from 18.18 and 3.68 % to 1.75 and 0.5%, respectively. These results were obtained at used 10 knives.

Effect of knives number

The Effect of knives number on percentage of cutting length was illustrated in Fig.(5). The general trend of this relationship was increasing knives number from 6 to 10 led to increase the cutting length percentage of categories < 0.5 cm and category 0.5-1 cm, while diminish the percentage of cutting length of categories 1-3 and > 3 cm.

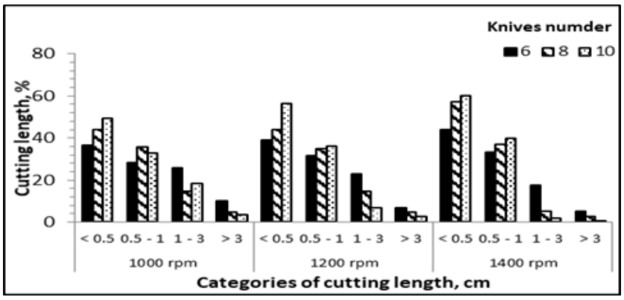


Fig. 5. Effect of knives speed on percentage of cutting length for orange peels.

Concerning results in Fig.(5) showed that increasing knives number from 6 to 10 led to increase the cutting length percentage at categories < 0.5 and 0.5-1 cm from 44.01 to 60.24% and from 33.28 to 39.69% respectively. Meanwhile, both the cutting length of categories 1-3 and > 3 cm were decreased from 17.49 to 1.75% and from 5.22 to 0.5%, respectively at the above same at the above same. These results were obtained at 1400 rpm.

The regression analysis to the effect of knives speeds (Ks), knives number (Kn) and cutting length categories (Ca) cleared the high significant effect on the cutting length (CL) "%". The regression equation and the coefficient of determination found as follow:

CL = 51.153 -0.004Ks + 0.208Kn - 15.952Ca (R^2 =0.7523)

Machine productivity

The productivity of the developed cutting and pressing machine is affected by many operational factors, such as knives speed and knives number. Fig. (6 and 7) show the machine productivity.

Effect of knives speed:

Data in Fig. (6) show the relationship between knives speed and machine productivity; the general trend of this relationship was that increasing knives speed led to increase the machine productivity.

It was noticed that increasing knives speed from 1000 to 1400 rpm (9.42 to 13.188 m/s) caused an increase in machine productivity from 90.96 to 120.98 kg/h at using 10 knives, as shown in Fig. (6). These results are in agreement with those reported by Nasr (2000) and EL-Khateeb and El-Keway (2012). By increasing the speed of knives, the machine becomes more productive because there is more cutting and pressing of the orange peel. But the percentage of oil and pectin was reduced.

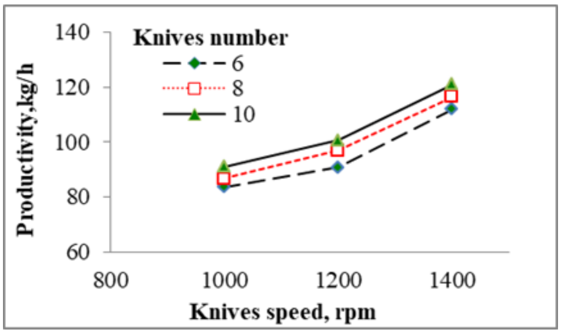


Fig. 6. Relationship between knives speed and machine productivity.

Effect of knives number:

The results in Fig. (7) show the relationship between knives number and machine productivity for orange peel. The general trend of this relationship was increasing knives number led to increase the machine productivity.

The results showed that at knives speed 1400 rpm, by increasing knives number from 6 to 10, the machine productivity increased from 111.98 to 120.98 kg/h respectively. These results are in agreement with those reported by EL-Khateeb and El-Keway (2012) and Barakat (2016). The increase in machine productivity by increasing the number of knives from 6 to 10 may be attributed to the increased of number of cutting edges which ease the process of cutting in a shorter time.

The regression analysis to the effect of knives speeds (Ks) and knives number (Kn) cleared the high significant effect on the machine productivity (P) "kg/h". The regression equation and the coefficient of determination found as follow:

$$P = -5.642 + 0.073\ Ks + 2.177Kn \qquad (R^2 = 0.9554)$$

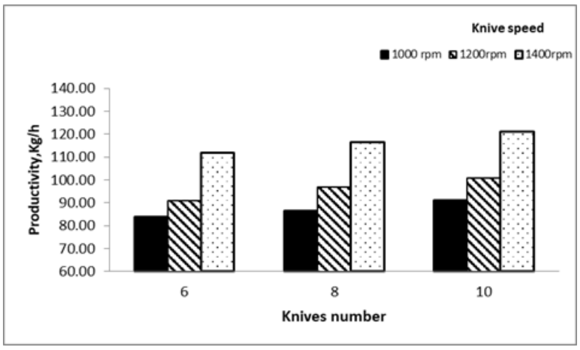


Fig. 7. Relationship between knives number and machine productivity.

3. Energy requirements

Energy requirements for machine operation was affected by many operational factors such as knives speed and knives number. Fig. (8 and 9) show the energy requirements for both cutting and pressing processes:

Effect of knives speed:

Fig. (8) Shows the relationship between knives speed and energy requirements; the general trend of this relationship was increasing knives speed led to decrease the energy requirements. It was noticed that increasing knives speed from 1000 to 1400 rpm (9.424 to 13.188 m/s) caused a decrease of energy requirements from 96.918 to 73.499 kW.h/Mg as shown in Fig. (8). Therefore, it appears that lower energy requirements were obtained at a higher speed of cutting knives. This attributed to the observed increasing of machine productivity rate at higher speeds of cutting knives. These results trend agreed with those obtained by Younis *et al.* (2002) and Elfatih *et al.* (2010).

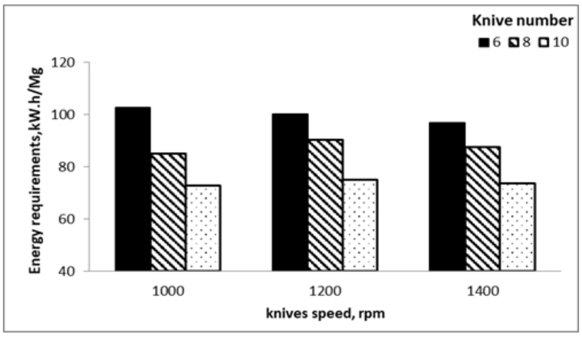


Fig. 8. Effect of knives speed on energy requirements.

To study the Effect of knives number on energy requirements, the knives speed was kept constant and the tests were conducted at levels of 1000 to1400 rpm (9.42 to13.188 m/s). Fig. (9) show the relationship between knives number and energy requirements; the general trend of this relationship was increasing knives number led to decrease the energy requirements.

The results in Fg. (9) showed that increasing knives number from 6 to 10, decreased the energy requirements from 102.629 to 73.499 kW.h/Mg , respectively. The results are in agreement with those reported by Barakat (2016).

The regression analysis to the effect of knives speeds (Ks) and knives number (Kn) cleared the high significant effect on the energy requirements (Er) "kW.h/Mg". The regression equation and the coefficient of determination found as follow:

$$Er = 173.329 - 0.061Ks - 1.379Kn \qquad (R^2 = 0.9764)$$

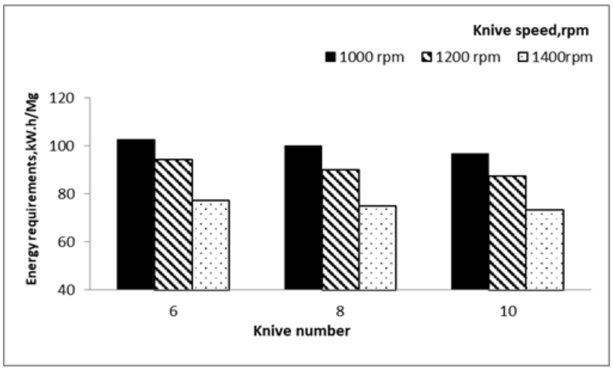


Fig. 9. Effect of knives number on energy requirements.

4. Operating Cost:

The machine cost was evaluated under the optimum operational condition of knives speed (1400 rpm and number of knives 10).The results show that under this operational condition production cost approached 233.75 LE/Mg.

6. Product material.

A- Effect of the tested parameters on the percentage of oil yield

The effect of cutting and pressing parameters on the percentage of orange peel oil yield illustrated in table (2). The percentage of oil yield for orange peel residuals remarkably affected by knives speed (1000, 1200 and 1400 rpm) and number of knives (6, 8 and 10). Generally, cutting and pressing the orange peel residues before distillation resulted in increasing or reducing the percentage of oil yield depending on time of cutting and pressing. The percentage of oil yield (7ml /100g. gross mass) was obtained from fresh orange peel residues when cutting the orange peel residues by serrated knives at 1000rpm and > 3 cm cutting length. This percentage of oil yield was lower by 2.17% g/100g d.w., than the condition of increasing the knives speed and decreasing the cutting length (< 0.5, 0.5 - 1 cm and 1400 rpm). In general, the highest percentage of oil yield ranged from 4.38 to 4.24% ml/100g d.w at knives speed 1400rpm and knives number 10.

Table 2. The effect of cutting and pressing processes on the percentage of oil.

cutting length, cm	knives speed, rpm		
	1000 rpm	1200 rpm	1400 rpm
< 0.5	4.18	4.27	4.38
0.5-1	3.98	4.13	4.24
1 – 3	3.95	4.08	4.17
> 3	2.24	2.61	2.84

The regression analysis to the effect of knives speeds (Ks) and cutting length categories (Ca) cleared the high significant effect on the percentage of oil yield (oil) "%". The regression equation and the coefficient of determination found as follow:

$$Oil = 3.773 + 0.0008\ Ks - 0.680Ca \quad (R^2 = 0.9075)$$

B- Effect of the tested parameters on the percentage of pectin

The effect of cutting and pressing parameters on the percentage of orange peel pectin are illustrated in Fig. (10). The percentage of pectin remarkably affected by knives speed (1000, 1200 and 1400 rpm) and knives number (6, 8 and 10). Generally, cutting and pressing the orange peel residues before distillation affected the percentage of pectin depending on time of cutting and pressing. Cutting the orange peel resides by 1400 rpm reduced the pectin percentage to 2.17% g/100g d.w. while increasing the knives speed and decreasing the cutting length (< 0.5, 0.5 - 1 cm).Under the operational condition the percentage of pectin increased to 40.89, 36.19% g/100g d.w. for the coarse and fine peels, respectively. The highest pectin was obtained at knives speed 1400rpm and knives number of 10.

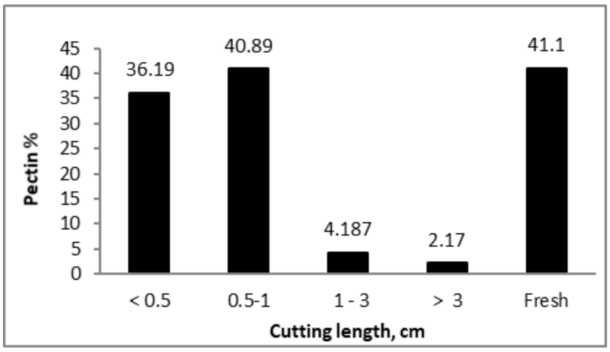


Fig. 10. The effect of cutting and pressing treatments on the pectin percentage for orange peel residuals.

CONCLUSION

To get the highest productivity and lowest energy regardless of oil and pectin production it is recommended to operate the machine at the above levels of the studied variables. To achieve the highest ratio of small cutting lengths (< 0.5, 0.5 - 1 cm) that are suitable for getting the highest percentage of pectin and oil extraction process, it is recommended to operate the machine according to the following parameters: the speed of the knives is 1400 rpm and the number of serrated knives is 10.

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تعظيم الأستفادة من بعض مخلفات التصنيع الغذائي

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الملخص

يهدف هذا البحث الى تعظيم الاستفادة من بعض مخلفات التصنيع الغذائى وأجريت هذه الدراسة لاختبار وتقييم فوائد مخلفات قشر البرتقال. تم التحقيق في المعاملات التالية؛ ثلاث سرعات لقطع السكاكين المسننة 1000 , 1200 و 1400 لفة/دقيقة (9,42- 11,304 و 13,188 م / ث) وثلاث سكاكين عدد 6 , 8 و 10 وسرعة البريمة ثابتة 60 لفة /دقيقة. تم أخذ المؤشرات التالية بعين الاعتبار للتحقق من أداء القطع: إنتاجية الماكينة (كجم/ساعة)، النسبة المئوية لطول القطع (%)، متطلبات الطاقة (كيلووات.ساعة/مجم)، تكلفة التشغيل (جنيه/مجم)، ونسب الزيت والبكتين. أشارت النتائج المتحصل عليها إلى أن أعلى قيم إنتاجية الماكينة لمخلفات قشور البرتقال كانت 120,98 كجم/ساعة. وكان الحد الأدنى لقيم متطلبات الطاقة وتكلفة التشغيل لمخلفات قشر البرتقال 73,50 كيلووات.ساعة/مجم و233.75جنيه/مجم على التوالي. تم الحصول على هذه النتائج في ظل الظروف التالية؛ سرعة السكاكين 1400 لفة/دقيقة (13,188 م/ث)، عدد 10 سكاكين. على الجانب الآخر، كما تم الحصول على أعلى نسبة من الزيت والبكتين على التوالى (4,38% ، 4,24%) و(40,89 ، 36,19%) عند طول القطع لمخلفات قشر البرتقال < 0,5، 0,5 - 1 سم عند نفس ظروف التشغيل السابقة.