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An Innovative Unit for Scraping Honeycombs

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ABSTRACT

An innovative unit has been constructed and tested for scraping honeycombs at Meet-Salseel, EL-Dakahliyah, Egypt. Scraping results in facilitating extraction of the maximum quantity of honey from the honeycombs. The main objective of this study is to solve the scraping problem by innovative a simple and easy operating unit for scraping honeycombs, by removing the caps without waste of honey, with minimum time and less number of labors. The innovative unit consists of a rectangular wooden frame attached by collecting tank. The innovative unit was compared to the conventional methods that included serrated stainless steel knife and a special scratcher. The experiments included three positions of scraping edges (horizontal, inclined and V-shape) and three blade angles (15, 30 and 45º). Scraping efficiency, weight of scraping part, scraping duration time and total cost were measured. Results showed that, the maximum value of scraping efficiency (100 %) was achieved with the simple innovative unit at V-shape position with 45º of blade angle. The minimum weight (92 g.) of scraping part was achieved by the simple innovative unit at horizontal position with 15º of blade angle. The minimum value of scraping duration time (22 sec.) was achieved by the simple innovative unit at V-shape position with 45º of blade angle. The innovative unit saved about 61.82 and 71.23 % of the operating cost compared to the conventional methods (serrated knife and scratcher), respectively. It is recommended to use the simple innovative unit at V-shape position, 45º of blade angle and in a hot room or at about 01:30 to 03:30 pm. to lessen the viscosity of honey.

Keywords: scraping, honeycombs, extraction, efficiency.

INTRODUCTION

Honeybee (*Apis mellifera*) is a winged, flower-feeding insect which have branched body hairs. They are dependent on pollen as a protein source and on flower nectar as an energy source. Bees are the most important pollinating insects. Their interdependence with green plant makes them an excellent example of the type of symbiosis known as mutualism; in which two parties of an unlike organisms benefits from each other. Bees produce honey mainly from the nectar of flowers, plant saps and honeydew. Honey consists of a mixture of sugars mostly glucose and fructose, in addition to water (usually 17- 20 %). It also contains very small amount of other substances like vitamins, minerals, proteins and amino acids (Babajide *et al*., 2015). According to the National Honey Board; pure honey is so unique in taste that does not need the addition of any other sweetening substance (Bogdanov and Stephen, 2009). Weaver and Weaver, (2000) reported that honey improves food assimilation and is used for chronic and infective intestinal problems such as duodenal ulcers, constipation and liver disturbance. It is also used as a facial cleanser and making hand lotion (Maddock and Jenkins, 2013). Because of these benefits, honey extraction is very important.

World production of natural honey and beeswax in 2017 was 39,297,788 and 22,722,346 metric tonnes, while in Egypt it was 4,570 and 110 metric tonnes, respectively (Faostat, 2017).

Moisture content, (amount of water in 100 g honey) which is a parameter that is related to climatic conditions, season of the year and the degree of honey maturity (Terrab *et al*., 2004) is quantitatively the second most abundant component of honey apart from sugars. Its content is quite critical, as it affects honey storage (Nanda *et al*., 2003). The density of honey is an important physical property that influences stratification in honey. Honey density is slightly greater than that of water although it depends on the water content of honey (Nanda *et al*., 2003). The extent of mixing and the ultimate moisture content of honey in the storage tanks will depend on the individual specific gravity of different types of honey (Moar, 1985). Liquids with this behavior are referred to as Newtonian liquids. From the literature, many honey varieties exhibit Newtonian flow behavior (Sopade *et al*., 2003). When honey is freshly extracted from honey combs, it is a viscous liquid and its viscosity depends on a large variety of substances and therefore varies with its composition and particularly its water content (Bhandari *et al*., 1999). Viscosity is an important technical parameter during honey processing because it affects honey flow during extraction, pumping, settling, and filtration, mixing and boiling (Yanniotis *et al*., 2006). The viscosity increases with agitation or stirring and therefore during honey processing, this important property must be taken into considerations (Yanniotis *et al*., 2006).

The honeybees dehydrate the nectar-honey until it reaches around 17% water and then they capping and sealing it off from air. The next step is to uncap the honeycombs. The wax capping are sliced off with a sharp long knife or special knives heated by steam or electricity or by capping scratchers (Jeff, 2002). There were some ancient patents for providing a machine which eliminates the use of knives or heat for uncapping honeycombs and provides a brushing effect for brushing away the honeycomb cap. Also an apparatus for uncapping wax from both sides of a honeycomb was invented. The apparatus comprises a pair of rotatable flails, a first conveyor for delivering a honeycomb to the pair of rotatable flails and a second endless conveyor for moving the honeycomb from the pair of rotatable flails. The pair of rotatable flails is located in a gab defined between the first and second endless conveyors (Gunness, 1988).

The conventional method is to remove the caps of the comb with a special knives and scratcher adapted to be artificially heated and this effect on honey quality. Because of the fact that honeycomb very often has a rough and uneven surface, the conventional method was found to be long, tedious and oftentimes wasteful of honey. Many countries in the world such as Britain, Australia, New Zealand, Germany, Brazil, USA, Nepal and India have carried out extensive research on their honey and as a result

have managed to design and fabricate extraction and processing equipment as well as setting favorable conditions for its use (Terrab *et al*., 2004). There is a special built stainless steel machine that uses two vibrating spring loaded knives to uncap both sides of the comb at the same time. Scraping machines are chain driven with forward and reverse controls and they are powered by electric motor (Ricciardelli and Albore, 1998). These machines are imported with foreign currency and can't be used by small or poor beekeeping in the developing countries like Egypt. The modern machines were not viable and very expensive. Therefore, the objective of this study is to innovate a simple manual unit (apparatus) for scraping honeycombs in order to reduce the honey loss, save time and costs. This innovative unit suitable for the middle (with 30 - 100 beehives) and small beekeepers.

MATERIALS AND METHODS

Bees (*Apis mellifera carnica carniolan*) from a private apiary at Meet-Salseel, EL- Dakahliyah, Egypt were used for nectar collection from two kinds of flowers (alfalfa and cotton crops). Honeycombs were collected from beehives at the end of the flowering season and used to determine the proper conditions for scraping process by the innovative unit.

The innovative unit description:

The simple innovative unit consists of a rectangular wooden frame with maximum outside dimensions of (600 x 450 x 250 mm) having spaced apart from the bottom and attached by collecting tank with outside dimensions of (1350 x 450 x 250 mm) having inclined bottom and upstanding sidewalls as shown in (Fig. 1). Cutting edge of a fixed sharp blade was used to scrape the honeycombs. When the topping beeswax separates from the honeycombs, it drops on a screen fixed above the collecting tank. The end lower side of the collecting tank is provided with honey outlet valve. The collecting tank is fixed in a position that enables the unit to be completely emptied with small tilt angle of 10º. The screen is fixed across the top of the collecting tank to prevent large pieces of wax and other impurities from entering the collecting tank. The whole innovative unit was fixed on four legs to be supported at a desirable height of 500 mm. Twenty-seven honeycombs were used to test the innovative unit. Six honeycombs were used for comparing experiments to conventional methods (serrated stainless steel knife and a special scratcher) with three replications for each. Once all the cells on both sides of the honeycomb are uncapped, it is placed in a manual or electric extractor. Using centrifugal force, the honey within the cells is extracted as the extractor spins. Once both sides of the honeycomb are empty from honey, the process is repeated with remaining honeycombs.

The primary experimental procedure:

A careful scraping was carried out at different angles for three positions. The stroke of capped comb must be slow and forceful to the cutting edge of a fixed sharp blade to select the optimum cutting angles that used safely to remove cappings and open the honey cells. The variance between the upper and lower capped cells was also measured. The optimum time was at about 01:30 to 03:30 pm. to lessen the viscosity of honey.

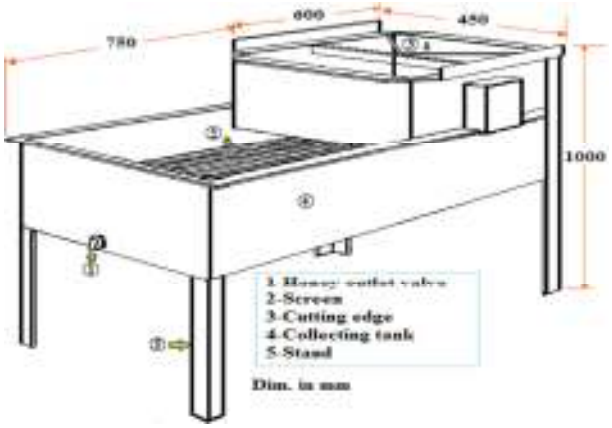

Fig. 1. The simple innovative unit.

Studied factors:

Scraping Methods

The innovative unit was constructed, tested and compared to the conventional methods that included serrated stainless steel knife with 30 cm length and 3 cm width and a special scratcher (Fig. 2).

Position of cutting edges

Three positions of cutting edge (horizontal, inclined and V-shape) are illustrated in Fig. 3. The angle between the cutting edge and the longitudinal side of the innovative unit was about 60º and 40º for inclined and V-shape positions, respectively (Fig. 3).

Cutting angles

Three angles of cutting blade (15, 30 and 45°) were tested.

Measurements:

Scraping efficiency:

Scraping efficiency ($\eta_{un.}$, %) is calculated for every honeycomb using the following relationship:

$$\eta_{un.} = \frac{A_{\text{before}} - A_{after}}{A_{\text{before}}} \times 100 \quad \rightarrow (1)$$

Where:

A_{after} = Area of capped and sealed cells after scraping process, cm^2.and,
A_{before} = Area of capped and sealed cells before scraping process, cm^2.

The nearest areas (cm^2) of capped honey cells were determined in all the experimental honeycombs by considering 4 cells per cm^2 of honeycomb.

Weight of scraping part:

Weight of scraping part was calculated by weighing every honeycomb before and after each treatment according to the following relationship.

$$W_{u.\,p.} = W_{before} - W_{after} \rightarrow (2)$$

Where:

$W_{u.p.}$ = Weight of scraping part, gram.
W_{before} = Weight of honeycomb before treatment, gram. and,
W_{afte} =Weight of honeycomb after treatment, gram.

Serrated Knife Scratcher Innovative unit

Fig. 2. Methods used for scraping honeycomb.

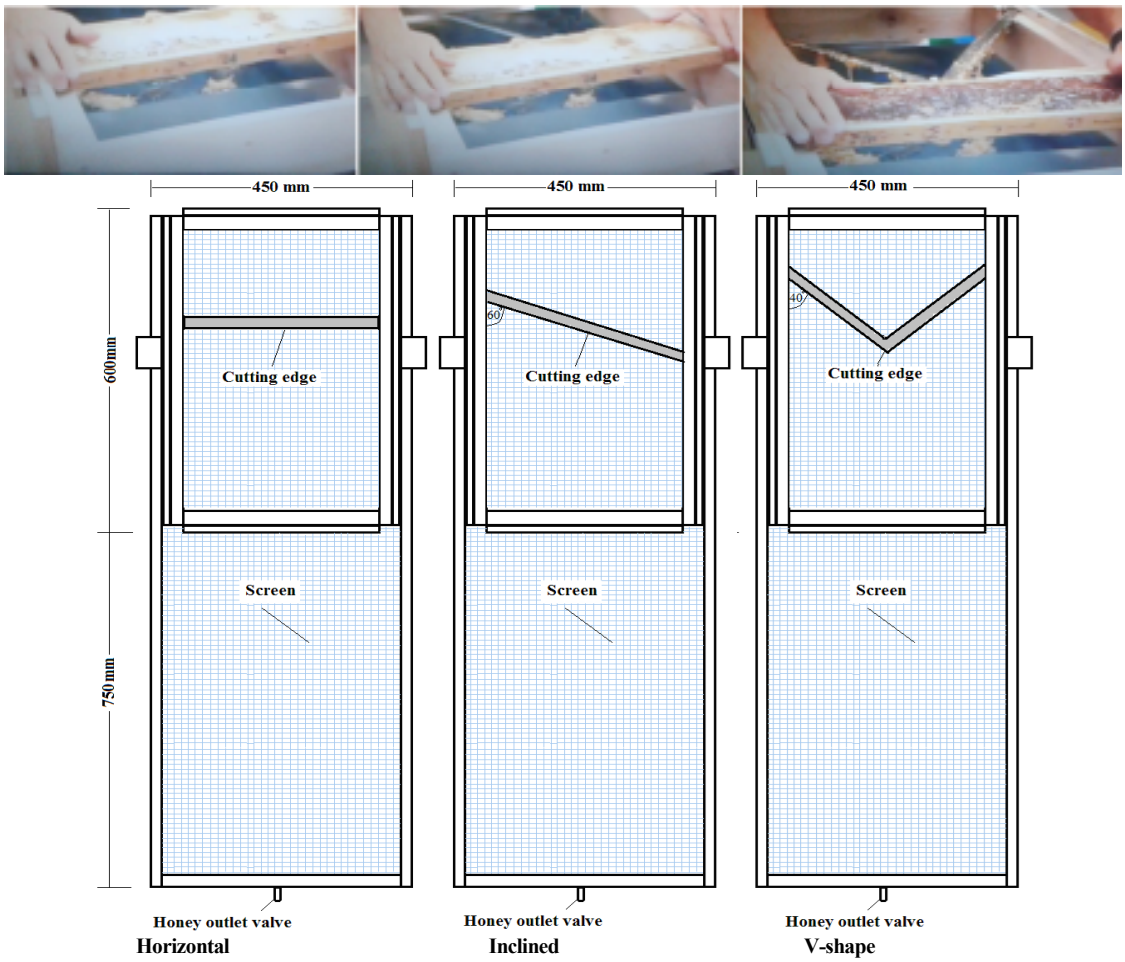

Fig. 3. Position of cutting edges

Scraping duration time (T):

The time needed (T) for scraping process is measured by a common stopwatch with an accuracy of 0.01 second.

Statistical analysis:

The obtained data are presented in figures and are analyzed statistically by using a computer program (SAS., 2012). The graphs were drawn using the Microsoft excel 2016.

RESULTS AND DISCUSSION

Effect of scraping method, position of cutting edge and angle of cutting blade on scraping efficiency:

Fig. (4) showed the effect of scraping method, positions of cutting edge and angles of cutting blade on scraping efficiency. There is an increment in scraping efficiency during using the simple innovative unit, due to the more accuracy during scraping process. The mean scraping efficiency increased from 83.33±2.60 with the common scraping method (serrated knife) to 96.88±0.45 with the simple innovative unit, while it was 88.33±0.88 with scratcher method. The mean scraping efficiency increases from 94.22±0.46 at the horizontal position to 99.33±0.28 at V-shape position, because, at this position, there is more stability and regular distribution of needed cutting force along the whole honeycomb. Because of the uneven surface of the honeycomb there were some lower capped cells. The highest mean scraping efficiency was 97.77±0.64 with 45º of blade angle, due to the more penetration of cutting blade enables to reach the lower capped cells. It was noticed that scraping efficiency increased with scraping method, cutting edge position and blade angle, according to the descending order (common serrated knife < common scratcher < the simple innovative unit); (horizontal < inclined < V-shape) and (15º < 30º < 45º), respectively. Results in Table (1) clearly demonstrated that, scraping method has highly significant effect on scraping efficiency. Knife method had the lowest value while the highest one was shown with innovative unit. Cutting position significantly affected scraping

efficiency. Maximum scraping efficiency is observed with V-shape position while the minimum value was shown with horizontal position. Concerning cutting angle, it had not significant effect on scraping efficiency, due to the less variance between the upper and lower capped cells for the new honeycombs used in this study. Blade angle (45º) coupled with the highest value compared to blade angle (15º) which coupled with the lowest estimate.

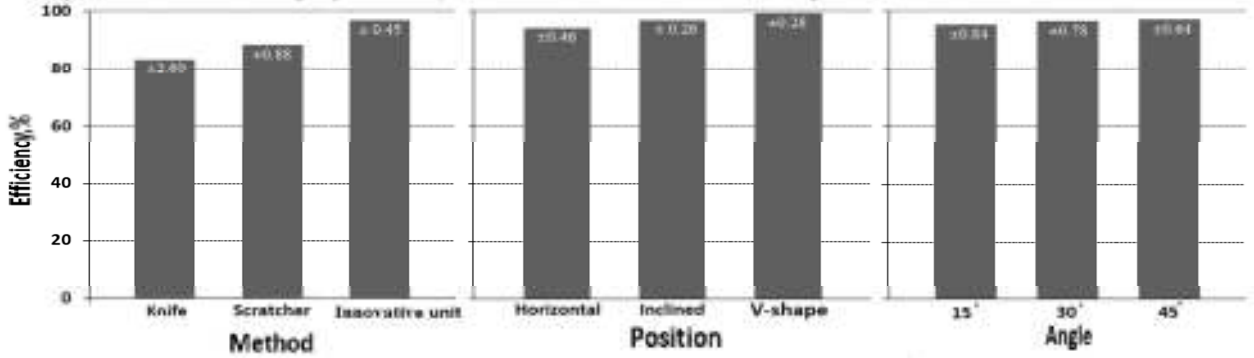

Fig. 4. Effect of scraping method, position of cutting edge and angle of cutting blade on scraping efficiency.

Table 1. Means along with their standard error for scraping efficiency affected by studied factors.

Factors		Efficiency,%
Method	Innovative unit	96.88±0.45[a]
	Scratcher	88.33±0.88[b]
	Knife	83.33±2.60[c]
	P-value	<.0001
Position	V-shape	99.33±0.28[a]
	Inclined	97.11±0.26[b]
	Horizontal	94.22±0.46[c]
	P-value	0.0004
Angle	15º	95.77±0.84
	30 º	97.11±0.78
	45 º	97.77±0.64
	P-value	0.1906

Effect of scraping method, position of cutting edge and angle of cutting blade on weight of scraping part:

Fig. (5) showed the effect of scraping method, cutting edge position and angles of cutting blade on weight of scraping part. There is a decrement in scraping weight when scraping with the simple innovative unit, at horizontal position under 15º of blade angle, due to less penetration and consequently the less thickness of cutting layer. The mean weight decreased from 182±4.04 g. with the common serrated knife to 121.62±3.51 g. with the simple innovative unit, while it was 170.33±9.59 g. with the common scratcher, due to the more careful while cutting with the innovative unit. The mean weight decreases from 140.22±2.78 g. at V-shape to 100.77±2.77 g. at horizontal position. The lowest mean weight was 112.77±5.79 g. with 15º of blade angle. It was noticed that weight of scraping part decreased with scraping method, cutting edge position and blade angle, according to the descending order (common serrated knife < common scratcher < the simple innovative unit); (V-shape < inclined < horizontal) and (45º < 30º < 15º), respectively. Results in Table (2) indicated that scraping method had highly significant effect on weight of scraping part. Maximum and minimum estimates are observed with knife and innovative unit, respectively. Moreover, the different levels of cutting position affected weight of scraping part significantly. Higher and lower estimates are shown with V-shape and horizontal positions, respectively. For blade angle, it had not significant effect on weight of scraping part, blade angle (45º) coupled with the highest estimates compared to blade angle (15º) which coupled with the lowest estimates.

Effect of scraping method, position of cutting edge and angle of cutting blade on scraping duration time:

Fig. (6) showed the effect of scraping method, cutting edge position and angles of cutting blade on scraping duration time. There is a decrement in time when using the simple innovative unit at V-shape position and at 45º of blade angle, due to the less friction area between cutting blade and honeycomb at 45º, more control and easy act when drawing the honeycomb on the cutting edge at V-shape position. The mean time decreased from 132.33±2.90 sec. with scratcher method to 32.48±1.15 sec. only with the innovative unit, while it was 77.33±6.17 sec. with the serrated knife. The mean time decreased from 37.77±1.57 sec. at inclined position to 27.77±1.59 sec at V-shape position, because of more balance and easy drawing when distributing the cutting force at two equal sides with V-shape position. Lower mean time was 27.22±1.46 sec. at 45º of blade angle. It was noticed that duration time, decreased, with scraping method, cutting edge position and blade angle, according to the descending order (the simple innovative unit > common serrated knife > common scratcher); (V-shape > horizontal > inclined) and (45º > 30º > 15º), respectively.

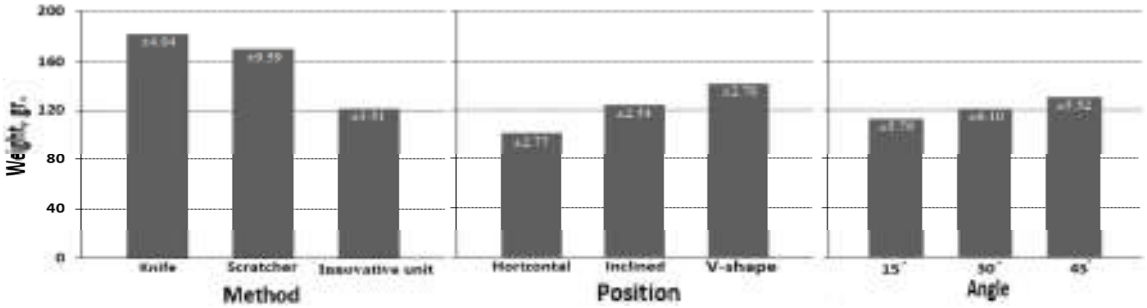

Fig. 5. Effect of method, position of cutting edge and angle of cutting blade on weight of scraping part.

Table 2. Means along with their standard error for weight of scraping part affected by studied factors.

Factors		Weight, gram
Method	Innovative unit	121.62±3.51[b]
	Scratcher	170.33±9.59[a]
	Knife	182.00±4.04[a]
	P-value	<.0001
Position	V-shape	140.22±2.78[a]
	Inclined	123.88±2.54[b]
	Horizontal	100.77±2.77[c]
	P-value	<.0001
Angle	15º	112.77±5.79
	30 º	122.00±6.10
	45 º	130.11±5.52
	P-value	0.1297

Results in table (3) demonstrated that scraping method had highly significant effect on scraping duration time. Higher and lower values for scraping duration time were recorded with scratcher and innovative unit, respectively. In addition, the different levels of cutting position affected scraping duration time significantly. Higher and lower values were shown with inclined and V-shape positions, respectively. With regard to blade angle, it had significant effect on scraping duration time. Higher and lower values were recorded with blade angles (15º and 45º), respectively, due to the more friction area between cutting blade and honeycomb at 15º.

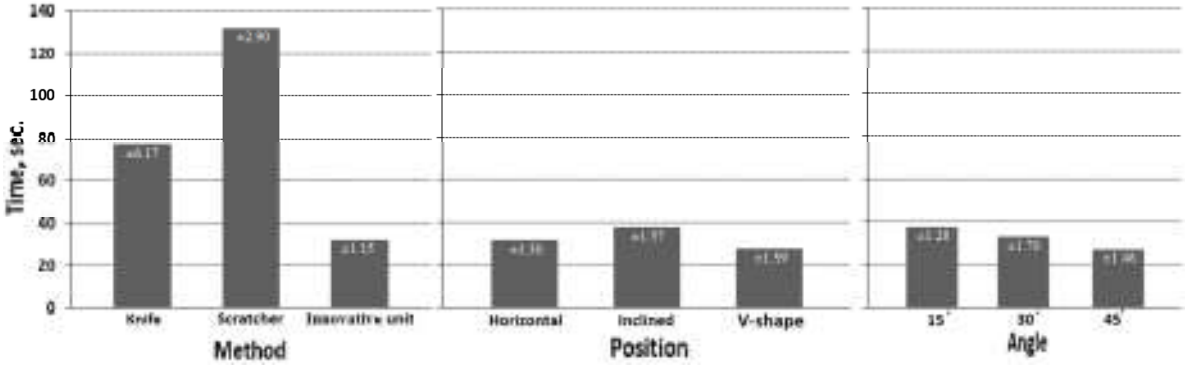

Fig. 6. Effect of method, position of cutting edge and angle of cutting blade on scraping duration time.

Table 3. Means along with their standard error for scraping duration time affected by studied factors

Factors		Time, sec.
Method	Innovative unit	32.48±1.15[c]
	Scratcher	132.33±2.90[a]
	Knife	77.33±6.17[b]
	P-value	<.0001
Position	V-shape	27.77±1.59[b]
	Inclined	37.77±1.57[a]
	Horizontal	31.88±1.30[b]
	P-value	<.0001
Angle	15º	37.22±1.28[a]
	30 º	33.00±1.70[a]
	45 º	27.22±1.46[b]
	P-value	0.0004

Cost analysis:

Table (4) showed a comparison between the total cost of the innovative unit and the conventional methods. The total cost of the simple scraping method was 0.21 L.E./honeycomb compared to the conventional methods that used serrated stainless steel knife (0.55 L.E./honeycomb) and the special scratcher (0.73 L.E./honeycomb), as the innovative unit needs one labor to uncap a number of 330 honeycombs at three hours compared to the conventional methods (serrated knife and scratcher) that need three and four labors, respectively to finish the same number of honey combs in the same time. The innovative unit saved about 61.82 to 71.23 % of the total cost compared to the conventional methods (serrated knife and scratcher). Generally, manual methods are used in Egypt for scraping honeycombs, which is costly, as there is a great increase in labors wages and there are some efforts in dealing with honeybees.

Table 4. Comparison between the total cost of the innovative unit and the conventional methods.

Specification	Knife	Scratcher	Innovative unit
Total price, L.E.	70	110	1000
Operating hours/ 5year	5x20x3= 300	5x20x3= 300	5x20x3= 300
Operating cost, L.E./hr.	$\frac{70}{300}=0.23$	$\frac{110}{300}=0.37$	$\frac{1000}{300}=3.33$
Labor costs, L.E./hr.	3x20=60	4x20=80	1x20=20
The total cost, L.E./honeycomb	$\frac{60.23}{110}=0.55$	$\frac{80.37}{110}=0.73$	$\frac{23.33}{110}=0.21$

CONCLUSION

The results could be summarized at the following main points:

- The maximum value of scraping efficiency (100 %) was achieved with the simple innovative unit at V-shape position with 45º of blade angle.
- The minimum weight (92 g.) of scraping part was achieved by the simple innovative unit at horizontal position with 15º of blade angle.
- The minimum value of scraping duration time (22 sec.) was achieved by the simple innovative unit at V-shape position with 45º of blade angle.

- Scraping of honeycombs with a manual operated knife or scratcher was slowly, tedious and required expert manipulation if the comb was not damaged.
- The innovative unit saved about 61.82 to 71.23 % of the operating cost compared to the conventional methods (serrated knife and scratcher).
- It is recommended to use the simple innovative unit at V-shape position, 45º of blade angle and in a hot room or at about 01:30 to 02:30 pm. to lessen the viscosity of honey.

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وحدة مبتكرة لكشط أقراص العسل

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تم تصميم واختبار وحدة مبتكرة لكشط أقراص العسل بمدينة ميت سلسيل محافظة الدقهلية – مصر.حيث يسهل الكشط استخراج أكبر كمية من العسل الموجود بالأقراص حيث تستخدم معدات حديثة ومعقدة ومرتفعة الثمن لا تتناسب والظروف المصرية. كما يتم الكشط التقليدي باستخدام سكاكين خاصة يتم تسخينها باستخدام البخار أو الكهرباء مما يؤثر علي جودة العسل. ولأن طبيعة سطح أقراص العسل خشنة وغير منتظمة فان استخدام الكشط التقليدي يأخذ وقت طويل وينتج عنه فقد في العسل وكما أن المعدات الحديثة غير متوفرة ومرتفعة الثمن. لذا تهدف الدراسة إلى ابتكار وحدة بسيطة وسهلة التشغيل لكشط أقراص العسل واستخراج أكبر كمية من العسل الموجود بالأقراص بأقل فاقد وأقل وقت وعدد من العمال. تتكون الوحدة المبتكرة من إطار خشبي مستطيل موضوع فوق وعاء ذو جوانب رأسية وقاعدة مائلة لتجميع نواتج الكشط. تم دراسة الطرق التقليدية باستخدام السكين وشوكة الكشط ومقارنتها بوحدة الكشط المبتكرة عند ثلاث أوضاع لسكينة الكشط وهي الوضع الأفقي والمائل وعلى شكل حرف V و ثلاث زوايا لسكينة الكشط (15 ، 30 ،45º) وتم قياس كل من كفاءة الكشط ووزن الشمع المكشوط وزمن الكشط والتكاليف الكلية وكانت أقصي قيمة لكفاءة الكشط (100 %) عند استخدام وحدة الكشط البسيطة وعند وضع حرف V لسكينة الكشط وزاوية 45º. وكان أقل وزن للجزء المكشوط (92 جم) عند استخدام وحدة الكشط البسيطة وعند الوضع الأفقي لسكينة الكشط وزاوية 15º وكان أقل زمن للكشط (22 ث) عند استعمال الطريقة البسيطة للكشط عند وضع حرف V وعند زاوية 45º. أدي استخدام الوحدة المبتكرة للكشط إلي توفير 61,82 ، 71,23 % من التكاليف عند المقارنة بالطرق التقليدية الأخرى والمتمثلة في استخدام السكين وشوكة الكشط علي الترتيب. لذا يوصى باستخدام الوحدة المبتكرة للكشط عند وضع حرف V وعند زاوية 45º وفى حجرة ذات درجة حرارة مرتفعة أو بعد الواحدة بعد الظهيرة حتى الرابعة عصرا وذلك لتقليل لزوجة العسل.