Zagazig J. Agric. Res., Vol. 41 No. (3) 2014 621-641

Zagazig Journal of Agricultural Research

http:/www.journals.zu.edu.eg/journalDisplay.aspx?JournalId=1&queryType=Master

MANUFACTURE AND PERFORMANCE EVALUATION OF EXTRACTION SYSTEM OF BEESWAX FOR LOCAL PRODUCTION

Samah E.A. Elmesalmy[1*], M.S-E. El-Shal[1] and A.F. Abd El-Mottaleb[2]

1. Agric. Eng. Dept., Fac. Agric. Zigzag Univ., Egypt

2. Agric. Eng. Res. Inst., (AENRT), Giza, Egypt

ABSTRACT

Experiments were carried out to manufacture and evaluate the performance of three extraction systems of beeswax. Study of developing the extraction systems aims reduction the cost and loss of beeswax during manufacturing to raise efficiency and production. Systems of extractor of beeswax were (direct solar energy (S), direct solar energy and electric heater (SHE), direct solar energy, electric heater and fan (SEHF)). The variables of this research were: Temperature degrees (50-60 -70 and 80°C), inclined angles of glass cover for solar wax extractor (7.5, 15.5 and 23°), and thickness of wax layer during extraction (5, 10, 15 and 20mm). The experimental results reveal that, the best extractor is (SHE). Which the highest production rate (49.02, 892.61, 279.24g/hr.) while the efficiency were (6.79%, 49.07%, and 72.53%). For three extraction systems S, S EH, S EHF resp. When the collector inclination angle slope was 23°, with temperature degree was 80°C and thickness of wax layer was 20mm.

Key words: Old comb., natural wax, bees wax, capping, solar collector, extraction systems.

INTRODUCTION

Beeswax is one of the important products because it is saving bee and all its 0products. Beeswax can be obtained from mud hive, broken comb during extraction of honey from the old combs which bees don't used again. Many scientists tried to use combs which made from other materials such as strong paper, plastic and aluminum but these failed because in the first kind the bees attempts destroyed the paper and in 2nd and 3rd kind large numbers of colonies were dead. When one the wax (animal, plants, and metals) used the beeswax refused drawn out of this comb and this comb considered debased wax. According to the ministerial decision No. 488 of 1958 the Egyptian standard specifications (2005). another problem was found in the wax production, however Egypt has 1.3 million colonies and produces 9.3 million kg honey and need 820 000 kg wax but it produces 671 000 kg wax only, so it need to be 149 000 kg for cover the local production. And now the wax is used in many fields, especially in the drugs and food manufacturing many important problems appeared that's where all local systems depends on sort of beeswax in boiling water reach to 100°C, this affected on the quality of wax and its natural properties and also leads to broken, inflexibility (*i.e.,* the melting point of wax between 63-69°C).

Yoshida and Yoshida (1991) found that the acceptance of queen larvae in beeswax queen cell cups was over 80%, but when the cups were made of candelilla, carnauba, montan, or paraffin waxes acceptance was only 27-60%. When colonies were given foundation made from the different waxes, they drew comb only on the beeswax foundation. Foundation made from paraffin wax mixed with 30-50% beeswax was drawn out, but very slowly.

Toledo and Nogueira-Couto (1995) processed three types of beeswax (new combs, old combs, cappings) were each processed by different methods: (A) solar wax melter, (B) steam

* **Corresponding author: Tel.** : +201150574872
E-mail address: samah_elsayed79a@yahoo.com

extractor, (C) manual press, (D) wax in burlap sack in water which is heated. Overall, average yields for new wax and cappings did not differ significantly, but the yield of old wax was only half as much. Methods A, B and C gave significantly more wax than D. For cappings, best yields were obtained using A or B, and for new wax any method except D; for old wax, C was the best.

Shayne and Umney (2003) stated that beeswax has a high melting point range, of 62 to 64°C (144 to 147 °F). If beeswax is heated above 85°C (185°F) discoloration occurs. The flash point of beeswax is 204.4°C (399.9°F). Density at 15°C is 0.958 to 0.970 g/cm^3.

Soteris (2004) mentioned that a survey of the various types of solar thermal collectors and applications is presented by initially, an analysis of the environmental problems related to the use of conventional sources of energy is presented and the benefits offered by renewable energy systems are outlined. Typical applications of the various types of collectors are presented in order to show to the reader the extent of their applicability. These include solar water heating, which comprise thermosyphon, integrated collector storage, direct and indirect systems and air systems, space heating and cooling, which comprise, space heating and service hot water, air and water systems and heat pumps, refrigeration, industrial process heat, which comprise air and water systems and steam generation systems, desalination, thermal power systems, which comprise the parabolic trough, power tower and dish systems, solar furnaces, and chemistry applications. As can be seen solar energy systems can be used for a wide range of applications and provide significant benefits, therefore, they should be used whenever possible.

Seeley *et al.* (2005) used behavioral experiments to compare the recruitment effectiveness of dances performed on combs built with beeswax foundation *vs.* plastic foundation. They found that combs built with plastic foundation are markedly poorer at transmitting the 250 Hz vibrations produced by dancing bees. Nevertheless Nathan (2007) stated that at present, solar energy conversion technologies face cost and scalability hurdles in the technologies required for a complete energy system. To provide a truly widespread primary energy source, solar energy must be captured, converted, and stored in a cost-effective fashion. New developments in nanotechnology, biotechnology, and the materials and physical sciences may enable step-change approaches to cost-effective, globally scalable systems for solar energy use.

Dizaji *et al.* (2008) found that a direct relationship between the production of honey bee and population of colony. Using long lasting comb may be offset by deleterious effects of old comb acting as a biological constraint on larval development In this research compared the quantity of brood produced, average body weight of adult bee and population of adult bees in hive on brood combs of either old and new bee wax. They added that there were significant differences between new and comb waxes in terms of brood population in years 2005 and 2006 ($P<0.01$), also the significant difference has been found for honey production and weight of honey bees between old and new combs wax at years 2005 and 2006. They concluded that, new combs are effective on brood development and honey production. Thus, could be suggesting that beekeepers should eliminate old combs from their operations.

Kaye and Laby (2013) stated that paraffin wax having a density of around 0.9 g/cm^3 it is insoluble in water, but soluble in ether, benzene, and certain esters. Paraffin is unaffected by most common chemical reagents, but burns readily.

So, objectives of this study are to:

1.Developing extractor system for beeswax.

2.Optimizing some different parameters affecting the performance of developed extractors.

3.Comparing between the developed extractors.

MATERIALS AND METHODS

Experiments were carried out through years of 2008/2012 at (a private farm El-Sharkia Governorate, Egypt when 30.59° latitude and 31.51° longitude), Central Workshop of Central Research Institute of Agricultural Engineering, and wax samples were analyzed in food industry laboratory National Research Center - to study impact of some transactions on the beeswax during melting beeswax by using some extractor under Egyptian climatic conditions.

Materials

The used wax

All tests were done using three types of beeswax:

Remnants of the cell the age combs are more than 5 years (old combs), Result of capping comb (capping). Waxy appendages (natural beeswax).

Properties of beeswax types before the melting:

Average length (33cm), Average width (50 cm) and Average thickness (5, 10, 15, 20) mm.

Types of impurities that are found in the beeswax

The impurities of remnants of the cell (old combs) found that honey, bees, wood, dust, skin exfoliation, metal wire and water.

The impurities of result of capping comb (capping) found that honey, bees, wood and water.

The impurities of waxy appendages (natural wax) dust, honey and water.

Equipment

Developed extraction system of beeswax

The developed extraction system consists of the following main parts (Fig.1).

Two external wood boxes (65 × 55 × 35 cm.), Insulator material (thermal wool between two boxes with 2.5 cm thickness). Aluminum layer to cover the internal sides of internal box and this layer doesn't paint with black colour in order not to affect with increased or decreased temperature and pollution of wax, two glasses cover for upper surface of the two boxes with 5 mm thickness, 2.5 cm between them to increase temperature inside extractor. Four fans in the upper part of box to flow the air chimney in front of them to change expel water vapor .and the inner box divided crosswise into two-parts the first is absorbed plate from stainless (0.7 mm 50 × 33 cm) there is space of 10 cm between them , The second glass cover it used for putting the wax before sorting under this plate in bottom of box, there is heater with power of 0.3 kilowatts crosswise of the extractor and the second is 3 nets; the first one is on the absorber surface put perpendienlar as barrier to the wax. The first purification process, the other two nets were put on pot to receive the sorting wax, the three nets were put crosswise (4 , 20, 56), respectively.

Methods

Experiments were carried out to evaluate the performance of the developed extractors (direct solar energy (S), direct solar energy and electric heater (SHE), direct solar energy, electric heater and fan (SEHF)) to optimize the values of the main operating parameters during extraction beeswax under Egyptian climatic conditions:

Experimental conditions

The performance of the developed extractor was experimentally measured under the following parameters:

- Systems of extractor of beeswax (direct solar energy (S), direct solar energy and electric heater (SHE) and direct solar energy, electric heater and fan (SEHF))
- Temperature degrees (50, 60 , 70 , 80) degree,
- Inclined angle of glass cover for solar wax extractor and inclined angle metallic base (7.5 , 15.5 , 23) degree.
- Thickness of wax layer during extraction (5, 10, 15, 20mm).

Measurements and determinations

Evaluation of the performance was based on the following indicators:

Eextraction efficiency (%)

Extraction efficiency was calculated using the following formula:

$$\text{Extraction efficiency (\%)} = (Mo / Mt) \times 100$$

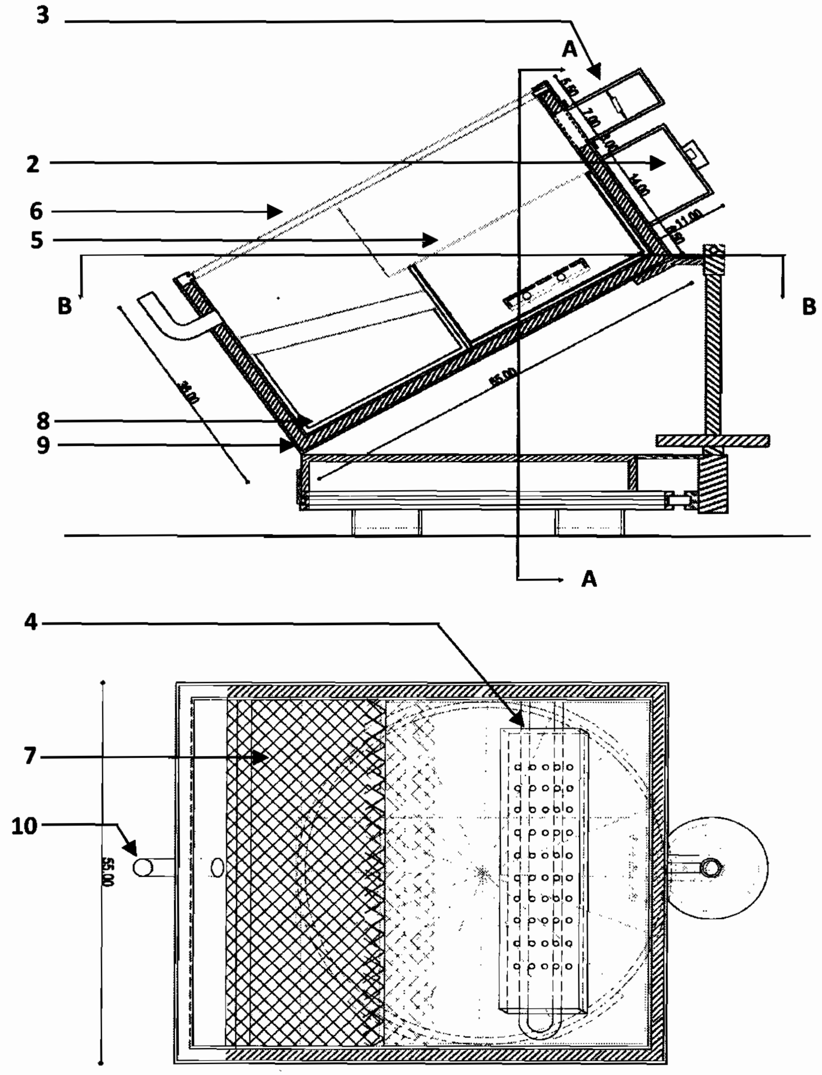
Where:

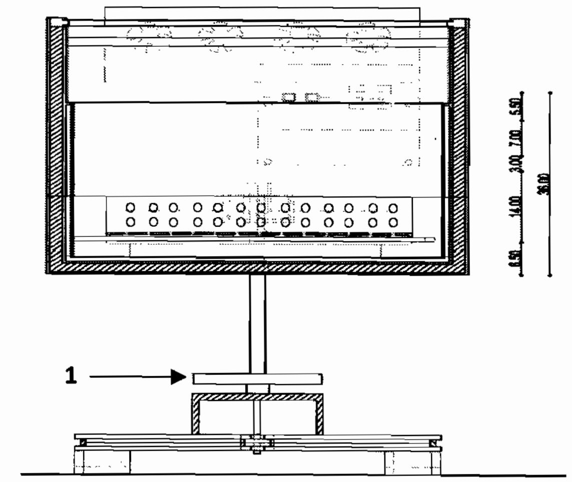
Mo = mass of extracted beeswax by the system,
Mt = the total mass of beeswax into the system.

System productivity (production rate)

System productivity was calculated using the following formula:

$$\text{System productivity (daily)} = (Mo \times HW) / t$$





No.	Part name
1	Manual Handling.
2	Electric Panel.
3	Air distributor.
4	Electric heater.
5	Solar collector.
6	Two sheets of glass.
7	Part demineralization.
8	Tray.
9	The body of the stomach.
10	Chimney.

Fig. 1. Elevation, side view and plan of extractor

Where:

t = the required time to extract the wax, HW = the number of working hours.

Power and energy requirement

Two kinds of power used in the systems

Total solar radiation (IT)

The total solar radiation falling had been collected on m^2 in two months June and September (1499.96, 1457.672) W/m^2

The all amount of radiation falling in an hour on surface titled collector on earth (Kaasm *et al.*, 2006).

$IT = I D + I d + I r$

Where :

$I D = I DN \times \cos \Theta$, $I d = C\ IDN\ Fss$, $I r = I TH\ \rho\ Fsg$.

I D = Direct total solar radiation W/m^2, IDN Direct normal solar radiation intensity

Θ Solar incident angle, I d diffuse sky radiation W/m^2, C a factor of diffused solar radiation

Fss a factor between surface collector and sky angle, I r = reflected from surrounding surfaces W/m^2

I TH solar radiation flux incident ion surface reflection, ρ a factor of surface reflection

Fsg a factor between surfaces received to reflected radiation and surface reflection angle

The total electric power (TPR)

$Ps = 1 \times V$

$Ph = ps \times (3600/1000)$

$TPR = ph \times t$

Ps= The power required for one second (W/s), Ph= the power required for one hour (kw/hr)

I = Intensity of the current (A), V= voltage (V), TPR= the total power required to extractor beeswax.

RESULTS AND DISCUSSION

The discussion will cover the obtained results under the following heads:

Effect of Sample Thickness on Production Rate for Developed Extractor (S) Using Different Kinds of Beeswax at (23°) Slope

Comparing the four thicknesses at 23° slope, results show that, in old combs the wax production rate increased by increasing the thickness (0.00, 3.21, 14.44, 23.94g/hr). This because increasing percentage of impurities due to the skin of larva and pupa inside the sixed eyes, these skins caused decreased the volume of skin eyes (Khetaby, 1981). Also old combs were dark and heavy due to impurities including egg, larvae and broad (Dizaji *et al.,* 2008). While in capping, the production rate of wax increased by increasing thickness (18.11, 36.97, 60.36 and 75.45g/hr) for 5, 10, 15 and 20mm thickness respectively. Also in natural wax, The production rate increased by increasing thickness (13.60, 27.33, 44.65, 51.13 g/hr) for 5,10,15 and 20 mm thickness respectively. From these results, we noticed that, 20 mm thickness was the best for the production rate of wax. Also, Capping has higher production rate than the other two types. As shown in Fig. 2. Our results agree with the finding of (Toledo and Nogueira-Couto, 1995) that studied three types of beeswax (new combs, old combs, capping) and reported that capping was the best for wax production.

Effect of Angle Solar Collector on Production Rate for Developed Extractor (S) Using Different Kinds of Wax at 20mm Thickness

As shown in Fig. 3 the obtained results show that, in old combs, there wasn't any wax production at 7.5 and 15.5 while in 23° slope the production rate was 0.62(g/hr).

In capping, the production of wax increased by increasing the angle solar collector. So, the rates of wax production were (44.56, 44.63, and 75.45g/hr) for 7.5, 15.5 and 23° slopes respectively.

Similarity, in Natural wax the rate of wax production at 23° (51.13g/hr) which increased than 7.5 and 15.5° (36.22, 33.27g/hr).

From these results, we noticed that, 23° slope was the best for the production rate of wax because when the angle solar collector increased, the acceleration rate of melting beeswax increased. Also, capping has higher rate of wax production than the other two types.

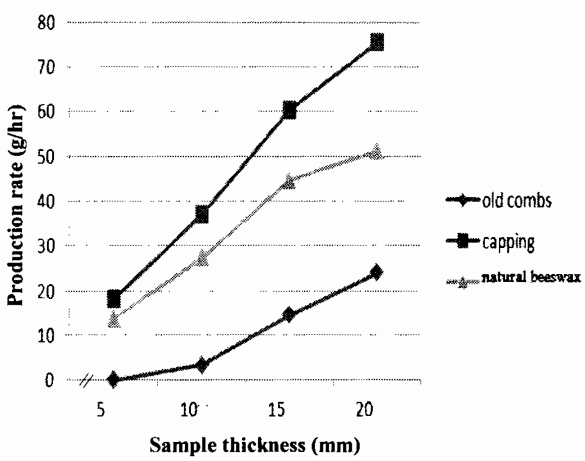


Fig. 2. **The effect of different sample thicknesses on production rate of wax extractor (S) in different kinds of wax at 23° angle solar collector and temperature from 50 to 80 °C**

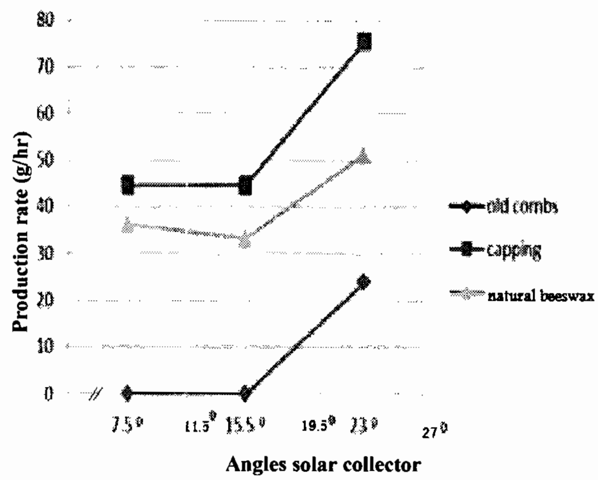


Fig. 3. **The effect of different angle solar collector on production rate of wax extractor (S) in different kinds of wax at 20mm thickness and temperatures from 50 to 80°C**

This may be due to the big size of impurities and increased the distance in between which caused the passing of liquid easily.

Effect of Sample Thickness on Efficiency for Developed Extractor (S) Using Different Kinds of Wax at 23° Slope

Comparing the four thicknesses at 23° slope, results show that, old combs (0.00%, 0.31%, 0.62%, 0.62%) weren't produce wax. in capping, the efficiency of extractor increased by increasing thickness until 15mm this due to increasing the sample weight. So it was (29.63%, 30.25%, and 32.92%) for 5, 10 and 15mm respectively, while at 20 mm (30.86%) and more the efficiency decreased. Also in natural wax, the efficiency of extractor increased by increasing thickness (40.74%, 42.59%, 48.97%) for 5, 10, 15 mm respectively. and decreased at 20mm (43.21%) and more. This because, up to 15 mm the sample thickness increased by which the direct sun light couldn't melt all this thickness.

From these results, it was noticed that, 15mm thickness was the best for all kinds of wax. Because production rate had maximum value at 15mm and after this thickness the direct sun light couldn't completely sorting. Also, natural wax has higher efficiency than the other two types (Fig. 4). This may be due to that natural wax has more amounts of wax and lower impurities than the other two types.

Effect of Angle Solar Collector on Efficiency for Developed Extractor (S) Using Different Kinds of Wax at 15 Mm Thickness

Data represented in Fig. 5 indicated that the efficiency presents only at 23° in old combs (0.62%). In capping efficiency increased by increasing angle solar collector. It was (23.46, 26.75 and 32.92%) for 7.5, 15.5 and 23° respectively.

These results were the same in natural beeswax which had (32.51, 39.09 and 48.97%) for 7.5, 15.5, and 23°, respectively. From these results, it was found that, 23° was the best for the production rate of wax because when the angle solar collector increased, the acceleration rate of the melting beeswax increased. Also, natural beeswax had higher percentage of wax production than the other two types. This may be due to that in natural beeswax the amount and size of impurities was less and smaller than the other two types.

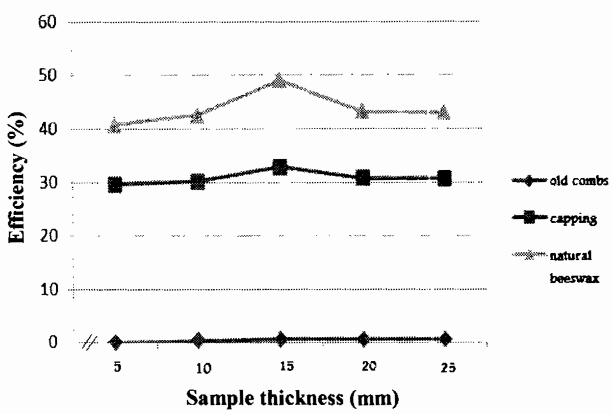


Fig. 4. The effect of different sample thicknesses on efficiency of wax extractor (S) in different kinds of wax at 23 ° slope and temperatures from 50 to 80°C

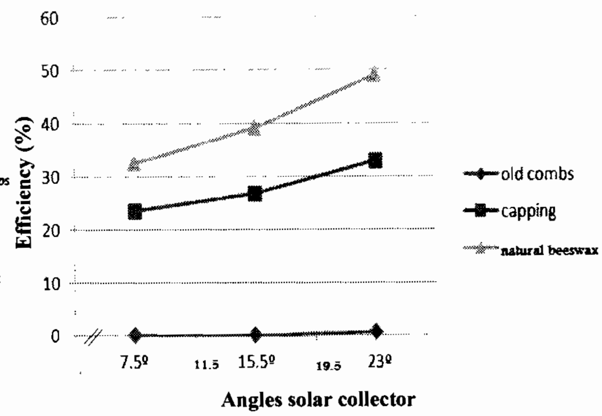


Fig. 5. The effect of different angle solar collector on efficiency of wax extractor (S) in different kinds of wax at 15mm thickness and temperatures from 50 to 80°C

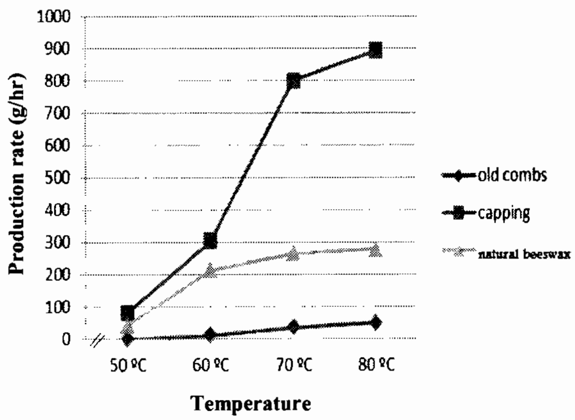
Effect of Temperature on Production Rate for Developed Extractor (SEH) Using Different Kinds of Wax at 23° and 20 mm Thickness

Fig. 6 represented the rate of wax production at 23° slope of 20 mm thickness at different temperatures for the three types of wax. The results showed that in old combs, at 50°C, there wasn't any production of wax in old combs, this because 50°C is less than the melting point of beeswax which is 64°C (Egyptian Organization for Standarization and Quilty, 2005; Shayne and Umney, 2003). While at 60°C the wax production was 12.02 g/hr and it was 35.65 and 49.02 g/hr for 70 and 80°C respectively. Similarly, in capping the wax production began from 60°C and increased by increasing temperature so it were (104.85, 880.35, 892.61 g/hr) for 60, 70, 80°C, respectively. Also, in natural beeswax the production rate was 214.48, 266.64 and 279.24 g/h for 60, 70 and 80°C respectively.

So, the data demonstrated that, the rate of wax production increased by increasing temperature until the highest rate at 80°C and this for all types of wax, this because when the liquid is heated the cohesive forces between the molecules reduce thus the forces of attraction between them reduce, which eventually reduces the viscosity of the liquids. Also, it was showed that, capping had more rate of wax production than the others this may be due to the big size of impurities and increased the distance in-between which caused the passing of liquid easily.

Effect of Sample Thickness on Production Rate for Developed Extractor (SEH) Using Different Kinds of Wax at 23° and 80°C

Comparing the four thicknesses at 23° slope and 80°C, showed that, capping had more rate of wax production (611.11, 665.10, 719.82, 892.61 g/hr) for 5, 10, 15and 20 mm respectively. While in natural beeswax and old combs the rate of wax production decreased (79.59, 141.30, 234.95, 279.24g/hr) and (22.49, 26.53, 31.96, 49.02g/hr) for 5, 10, 15and 20mm respectively. From these results, it was noticed that, 20mm thickness was the best for the production rate of wax for the three kind of wax because at this thickness the weight of sample increased and the electric heater gave continuous heat source in addition to the effect of direct sun light which increased melting the beeswax. It was also noticed that capping had higher rate of wax production than the other two types. This may be due to the big size of impurities and increased the distance in between which caused the passing of liquid easily. As shown as in Fig. 7.



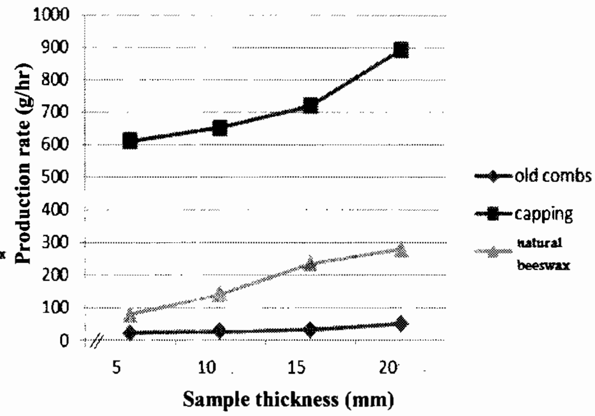


Fig. 6. The effect of different temperature degree on production rate of wax extractor (SEH) in different kinds of wax at 23 angle solar collector and 20 mm thickness

Fig. 7. The effect of different sample thicknesses on production rate of wax extractor (SEH) in different kinds of wax at 23 angle solar collector and 80°C

Effect of Angle Solar Collector on Production Rate for Developed Extractor (SEH) Using Different Kinds of Wax At 20mm Thickness and 80°C

In Fig. 8 the obtained results show that, in old combs, the production rate of wax increased by increasing angle slope (25.81, 33.99, 49.02g/hr) for 7.5, 15.5 and 23°, respectively. The same situation was observed in capping and natural beeswax which was (485.95, 504.61, 892.61g/hr) and (205.36, 224.21, 279.24g/hr) for 7.5, 15.5 and 23°, respectively.

From the results, 23° was the best slope for wax production. Because when the angle slope increased, the acceleration rate of the melting beeswax increased.

Effect of Temperature on Efficiency for Developed Extractor (SEH) Using Different Kinds of Wax at 23° and 20mm Thickness

In Fig. 9 concerning the old combs it was noticed that the efficiency increased by increasing temperature (5.46, 6.17 and 6.79% for (60, 70 and 80°C), respectively. So 80°C gave more efficiency. This situation also observed in capping and natural beeswax. Because when the temperature increases, the viscosity decrease, meaning that the adhering between molecules decrease caused increased sliding of the wax, so the efficiency increase. Also it was noticed that natural beeswax produced more wax than other two types meaning that the amount and size of impurities was more little and smaller.

Effect of Sample Thickness on Efficiency for Developed Extractor (SEH) Using Different Kinds of Wax at 23° and 80°C

Comparing the four thicknesses at 23° and 80°C, showed that, in old combs the efficiency increased by increasing thickness. It was (5.06, 5.5, 5.88 and 6.79%) for 5, 10, 15 and 20mm respectively. Natural beeswax highly increased than capping and the both highly increased than old combs as shown in Fig. 10. The results cleared that, 20mm thickness was the best for the efficiency of extraction for the three kinds of wax because at this thickness the weight of sample increased and the electric heater with fan gave continuous heat source with heat distribution in addition to the effect of direct sun light which increased melting the beeswax.

Effect of angle miles on efficiency for developed extractor (SEH) using different kinds of wax at 20 mm and 80 °C

The obtained results show that, in old combs, the efficiency of extraction slightly increased by increasing mile (5.59, 6.33, 6.79%) for 7.5, 15.5 and 23°, respectively. The same situation was observed in capping and natural beeswax, so the efficiencies were (42.28, 47.84, 49.07%) and (65.43, 69.14, 72.53%) for 7.5, 15.5 and 23° mile, respectively (Fig. 11).

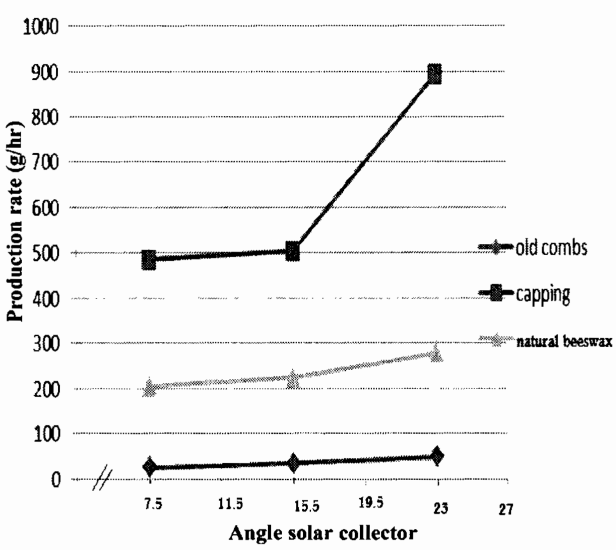


Fig. 8. The effect of different angle solar collector on production rate of wax extractor (SEH) in different kinds of wax at 20mm Thickness and 80°C

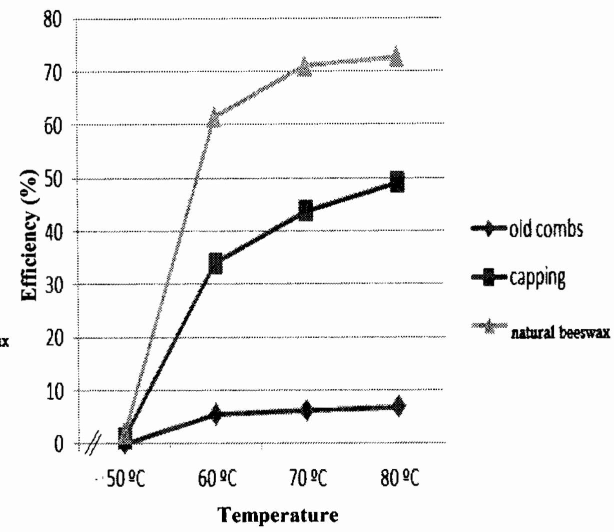


Fig. 9. The effect of different temperature degree on efficiency of wax extractor (SEH) in different kinds of wax at 23° angle slope solar collector and 20 mm thickness

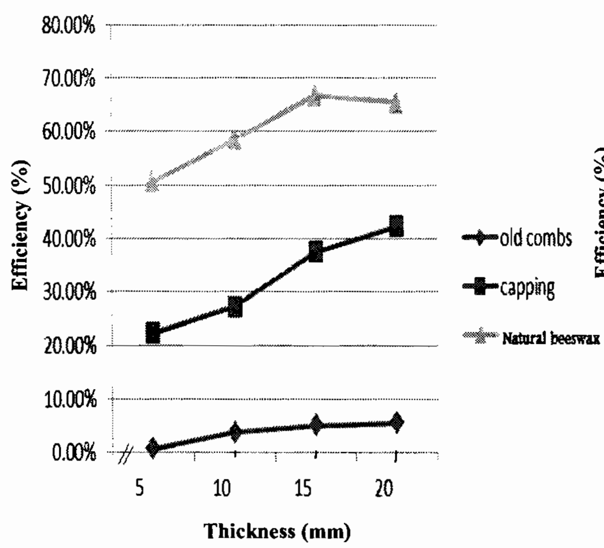


Fig. 10. The effect of different thicknesses on efficiency of wax extractor (SEH) in different kinds of wax at 23 angle solar collector and 80°C

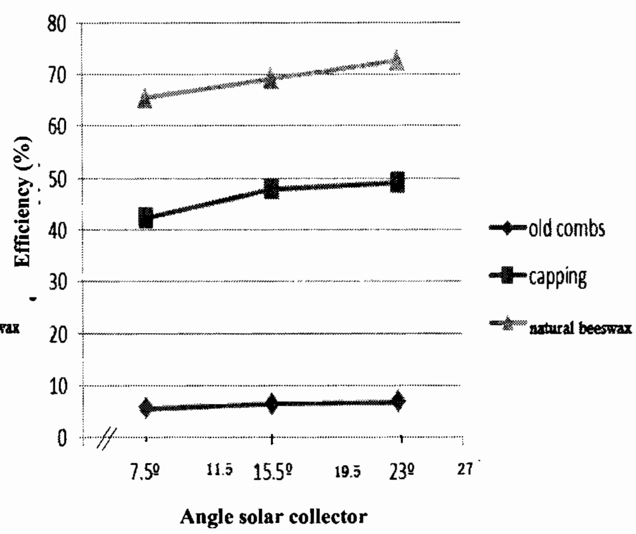


Fig. 11. The effect of different angle solar collector on efficiency of wax extractor (SEH) in different kinds of wax at 20mm and 80°C

From these results, noticed that, 23° slope is the best for the efficiency of extraction. Because when the angle slope increased, the acceleration rate of the melting beeswax increased. Also, natural beeswax has higher efficiency than the other two types because the total production of wax was higher in natural beeswax. This because increasing the amount of wax produced in this type than the others due to the little and small amount and size of impurities.

Effect of Temperature on Total Power Requires (TPR) for Developed Extractor (SEH) Using Different Kinds of Wax at 23° and 20mm Thickness

Fig. 12 represented the total power require to sort beeswax at 23° slope of 20 mm thickness at different temperatures for the three types of wax. The results showed that in old combs, the total power require increased at 60°C (27518.51 W) than 50°C (2620.81W). At 50°C there wasn't any melt to sample, while 60°C consider the beginning of the melting point of wax (Egyptian Organization for Standarization and Quilty, 2005). So, the extractor need more time to finish sort of sample. In contrast at 70°C (10483.24 W) and 80°C (8386.59 W) the total power requires decreased again than 60°C. This may be due to increasing temp which accelerates the processor of melting, so it needs shorter time than the low temp. The same situation was observed in the other two types of wax but natural beeswax need more total power require, because it needed more time to melt the wax due to small impurities in which didn't allow the liquid wax to pass easily through it.

Effect of Sample Thickness on Total Power Require (TPR) for Developed Extractor (SEH) Using Different Kinds of Wax at 23° and 80°C

Fig. 13 represented the effect of different thicknesses on the TPR at 23° slope and 80°C.

Concerning the old combs, it was noticed that TPR increased by increasing thickness (8648.64, 10876.37, 13104.05, and 12269.49 W) for 5, 10,15and 20mm, respectively. Also, in capping, the TPR increased by increasing the thickness, so, TPR were (3013.93.3378.06, 3616.72, 5739.58 W) for 5, 10, 15 and 20 mm thickness, respectively. Similarity, in natural beeswax the TPR increase (19262.96, 20966.49, 24449.73, 24643.89 W) by increasing thickness. From these results, we noticed that, 5mm thickness in capping had lower TPR, because 5mm thickness needs short time to sort all amount of wax due to its small amount, also, the type of wax affected this result (*i.e.,* capping has large size of impurities in which can pass easily through the wax so it need shorter time and the TPR was less.

Effect of Angle Slopes on Total Power Requires (TPR) for Developed Extractor (SEH) Using Different Kinds of Wax at 20mm and 80°C

In Fig. 14 the obtained results show that, in old combs, the TPR decreased by increasing the angle mile (13104.05, 11269.49, 8386.59W) for 7.5, 15.5and 23°, respectively.

The same situation was observed in capping and natural beeswax, so the TPR were (5739.58, 5291.42, 3328.43W) and (18347.68, 19131.92, 15724.86W) for 7.5, 15.5 and 23°, respectively. From these results, we noticed that, 23° slope was the lowest of TPR because the time decreased at this slope. Also, capping has lower TPR than the others two types due to decreasing the time needed to sort the beeswax. (*i.e.* the impurities in capping was larger than other, so it can pass easily so it need short time).

Effect of Temperature on Production Rate for Developed Extractor (SEHF) Using Different Kinds of Wax at 23° and 20 mm Thickness

Fig. 15 represented the rate of wax production at 23° of 20 mm thickness at different temperature degree for the three types of wax. The results showed that, at 50°C, there wasn't any production of wax in old combs, this because 50°C is less than the melting point of beeswax which is 64°C (Egyptian Organization for Standarization and Quilty, 2005; Shayne and Umney, 2003). At 60°C the wax production was 10.10g/hr and it was 28.52 and 34.82 g/hr for 70 and 80°C, respectively. Similarly, in capping the wax production began from 60°C and increased by increasing temperature so it was (70.28, 797.84, 717.50 g/hr) for 60, 70, 80°C. Also, in natural beeswax the production rate was

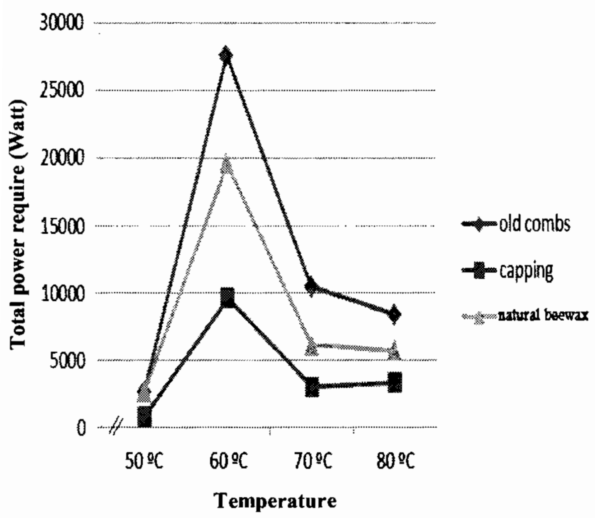


Fig. 12. Effect of temperature on total power require of wax extractor (SEH) at 23° and 20mm in different kinds of wax

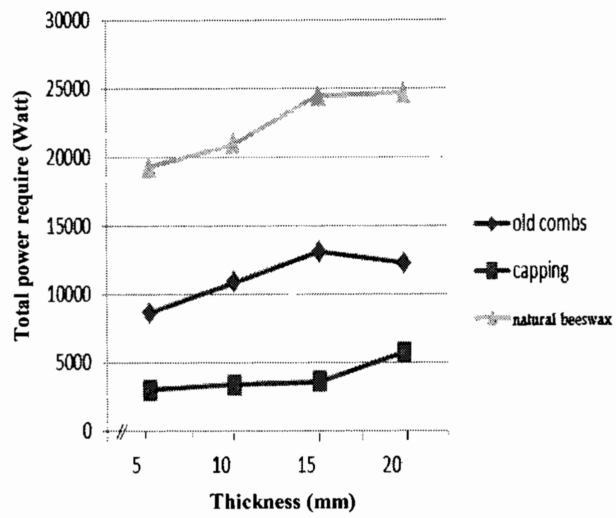


Fig. 13. Effect of thickness on total power require of wax extractor (SEH) at 23° and 80°C in different kinds of beeswax

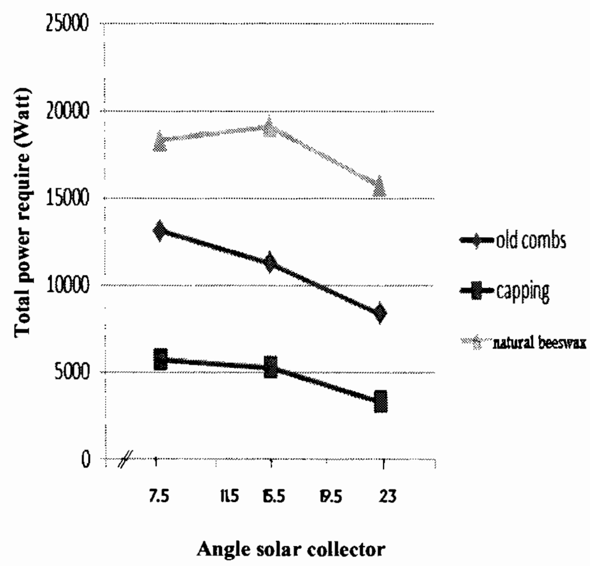


Fig. 14. Effect of angle slopes on total power require of wax extractor (SEH) at 20 mm thickness and 80°C in different kinds of wax

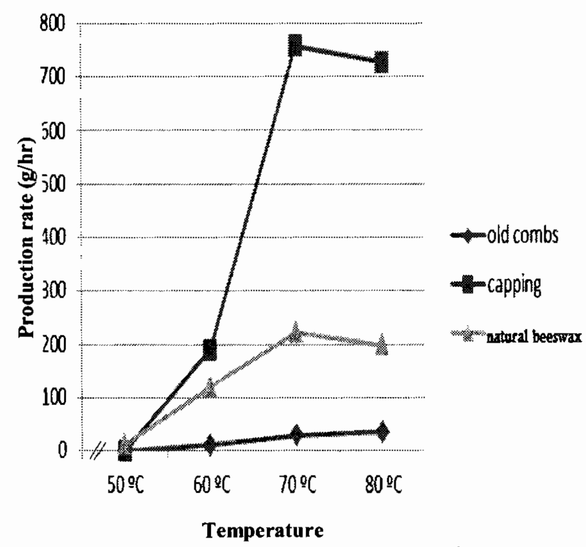


Fig. 15. Effect of temperature on production rate for developed extractor (SEHF) using different kinds of wax at 23° and 20 mm thickness

(121.04, 222.04 and 198.58 g/hr) for 60, 70 and 80°C. So, we noticed that, the rate of wax production increased by increasing temperature until reach the highest rate at 80 °C and this for all types of wax, this due to decrease the viscosity of wax by increasing temperature and vice versa so the sort of wax need shortest time. Also, results showed that, capping had more rate of wax production than the others; this may be due to the big size of impurities and increased the distance in-between which causes passing the liquid easily.

Effect of Sample Thickness on Production Rate for Developed Extractor (SEHF) Using Different Kinds of Wax at 23° and 80°C

In Fig. 16, the results showed that, capping had more rate of wax production (213.89, 403.70, 613.77, 717.50 g/hr) for 5, 10, 15 and 20 mm respectively. While in natural beeswax and old combs the rate of wax production decreased (67.02, 124.04, 165.30, 198.58 g/hr) and (12.67, 19.01, 33.27, 34.82 g/hr) for 5, 10, 15and 20mm, respectively. From these results, it could be noticed that, 20mm thickness was the best for the production rate of wax for the three kinds of wax because at this thickness the weight of sample increased and the electric heater with fan gave continuous heat source with heat distribution in addition to the effect of direct sun light which increased melting the beeswax. It is also noticed that capping has higher rate of wax production than the other two types, this may be due to the big size of impurities and increased the distance in between which caused the passing of liquid easily.

Effect of Angle Slopes on Production Rate for Developed Extractor (SEHF) Using Different Kinds of Wax at 20mm Thickness and 80°C

In Fig. 17, the obtained results show that, in old combs, the production rate of wax increased by increasing angle slope (25.16, 26.6, 34.82g/hr) for 7.5, 15.5 and 23° slope, respectively. The same situation was observed in capping and natural beeswax which were (358.62, 499.74, 717.5 g/hr) and (176.34, 131.9, 198.58 g/hr) for 7.5, 15.5 and 23°, respectively. We noticed that 23° slope was the best for wax production. Because in 23° slope the sliding of liquid increased and the time decreased so the production rate increases.

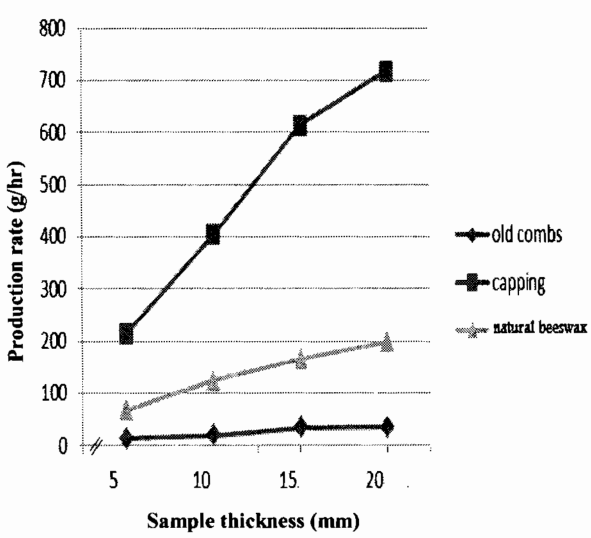


Fig. 16. Effect of sample thickness on production rate for developed extractor (SEHF) using different kinds of wax at 23° and 80°C

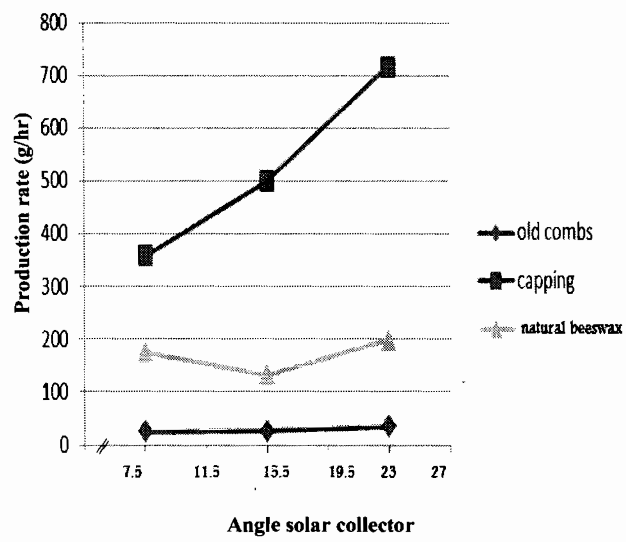


Fig. 17. Effect of angle solar collector on production rate for developed extractor (SEHF) using different kinds of wax at 20 mm thickness and 80°C

Effect of Temperature on Efficiency for Developed Extractor (SEHF) Using Different Kinds of Wax at 23° Slope Mile and 20 mm Thickness

In Fig. 18 concerning the old combs it was noticed that at 50°C there wasn't any wax production while at 60°C the wax began to produce, so the efficiency increased by increasing temperature (5.25, 6.17 and 6.48) for 60, 70 and 80°C, respectively. So 80°C gave more efficiency. This situation also observed in capping and natural beeswax. The explanation in our opinion is that when the temperature increases, the viscosity decreased meaning that the adhering between molecules decrease caused increased sliding of the wax, so the efficiency increased. Also it was noticed that natural beeswax produced more wax than other two types meaning that the amount and size of impurities were more little and smaller.

Effect of Sample Thickness on Efficiency for Developed Extractor (SEHF) Using Different Kinds of Wax at 23° Slope and 80°C

Comparing the four thicknesses at 23° slope and 80°C, results showed that, in old combs the efficiency increased by increasing thickness. It was (4.94, 4.94, 5.76 and 6.48%) for 5, 10, 15 and 20mm, respectively. Natural beeswax (58.02, 66.05, 68.31, 70.06%) highly increased than capping (37.04, 39.51, 40.74, 48.77%) for 5, 10, 15 and 20mm, respectively. The both highly increased than old combs in Fig. 19. From these results, it was noticed that, 20mm thickness is the best for the efficiency of extraction for the three kinds of wax. Due to increase the amount of wax produced in this thickness. Also natural wax had more efficiency than other two types meaning that the amount and size of impurities was more little and smaller.

Effect of Angle Slopes on Efficiency for Developed Extractor (SEHF) Using Different Kinds of Wax at 20mm Thickness and 80°C

The obtained results show that, in old combs, the efficiency of extraction slightly increased by increasing mile (5.56, 6.17, 6.48%) for 7.5, 15.5 and 23° slope, respectively (Fig. 20).

Natural wax (64.51, 68.52, 70.06%) more highly than capping (41.98, 46.30, 48.77%) for 7.5, 15.5 and 23° slope respectively. From these results, we noticed that, 23° slope is the best for the efficiency of extraction. This because at 23° slope the amount of wax produced increased.

Effect of Temperature on Total Power Require (TPR) for Developed Extractor (SEHF) Using Different Kinds of Wax at 23° Slope and 20 mm Thickness

The total power require to sort beeswax at 23° slope mile of 20 mm thickness at different temperatures for the three types of wax are represented in Fig. 21.

Concerning old combs, it noticed that the total power require highly increased at 60°C (31830.49 W) than 50°C (2652.54 W). At 50°C there wasn't any melt to sample while 60°C consider the beginning of the melting point of wax (Egyptian Organization for Standarization and Quilty, 2005) so; the extractor need more time to finish the melt of sample. In contrast the TPR decreased by increasing temperature at 70°C (12326.71W) and 80°C (11405.93W). This may be due to increasing temp. Which accelerate the processor of melting, so it needs shorter time than the low temperature. The same situation was observed in the other two types of wax but natural wax need more total power require (7957.62, 29841.09, 22567.79, 21618.21 W) than capping (2652.54, 27984.31, 4342.20, 4164.49 w) for 50, 60, 70 and 80°C, respectively. this because natural wax need more time to melt the wax due to the small impurities in it which didn't allow the liquid wax to pass easily through it (*i.e.* the basic factor affecting TPR is the time).

Effect of Sample Thickness on Total Power Requires (TPR) for Developed Extractor (SEHF) Using Different Kinds of wax at 23° Slope and 80°C

In Fig. 22 concerning the old combs, it was noticed that TPR increased by increasing thickness (5968.22, 7957.62, 7957.62 and 11405.93 W) for 5, 10, 15 and 20mm, respectively. Also, in capping, the TPR increased by increasing the thickness. So, TPR was (2652.54, 2928.39, 3050.42, 4164.49W) for 5, 10, 15 and 20 mm thickness, respectively. Similarity, in natural wax the TPR increase

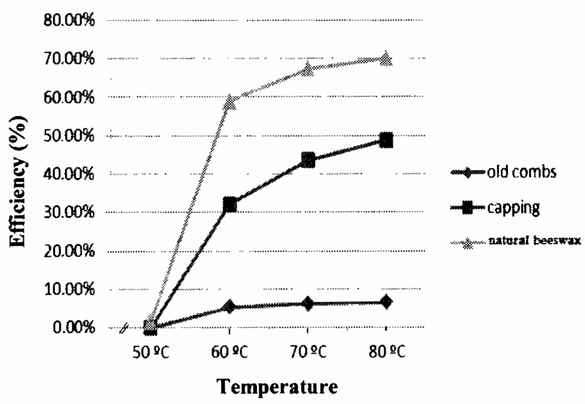


Fig. 18. Effect of temperature on efficiency for developed extractor (SEHF) using different kinds of wax at 23° slope and 20 mm thickness

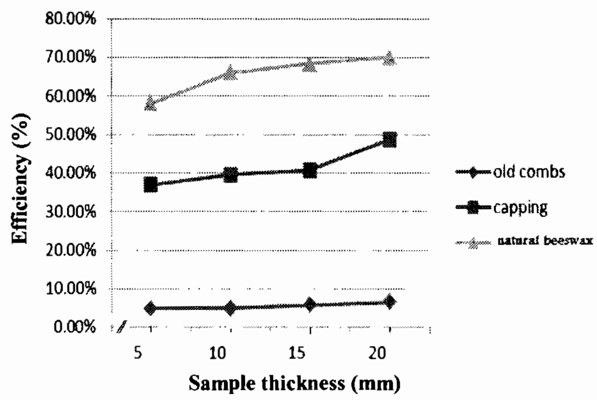


Fig. 19. Effect of thickness on efficiency for developed extractor (SEHF) using different kinds of wax at 23° slope and 80°C

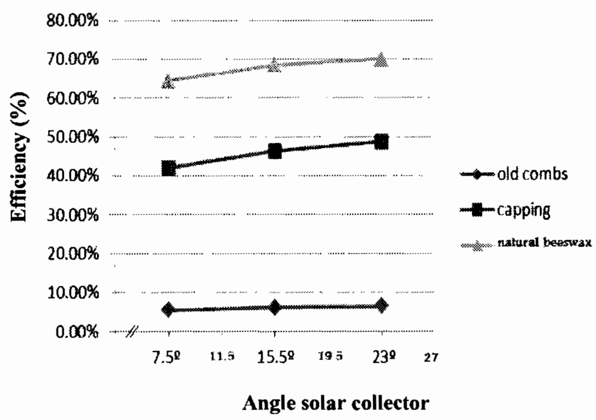


Fig. 20. Effect of angle solar collector on efficiency for developed extractor (SEHF) using different kinds of wax at 20mm thickness and 80°C

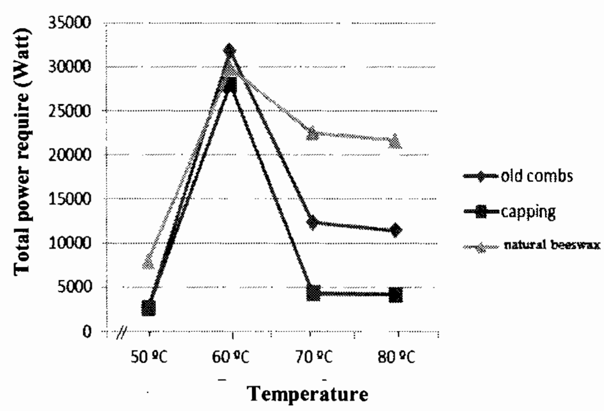


Fig. 21. Effect of temperature on total power require (TPR) for developed extractor (SEHF) using different kinds of wax at 23° slope and 20 mm thickness

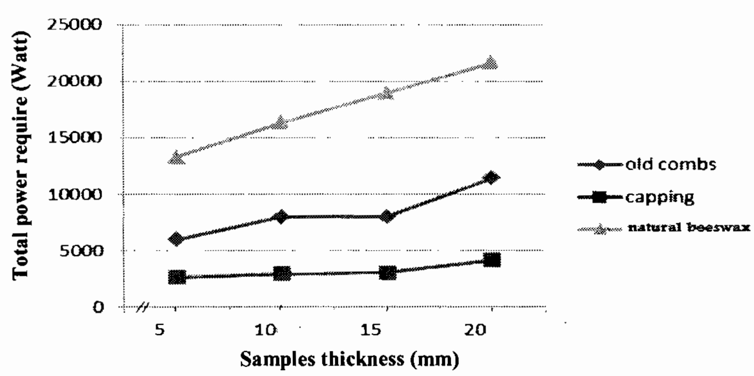


Fig. 22. Effect of thickness on total power require (TPR) for developed extractor (SEHF) using different kinds of wax at 23° slope and 80°C

(13262.71, 16313.13, 18992.19and 21618.21 W) by increasing thickness. From these results, we noticed that, 5mm thickness in capping had lower TPR. Because it needs short time to sort all amount of wax in 5 mm thickness due to its small amount, also. The type of wax affected this result (*i.e.,* capping has large size of impurities in which can passing easily through the wax so it need shorter time and the TPR was less).

Effect of Angle Slopes on Total Power Requires (TPR) for Developed Extractor (SEHF) Using Different Kinds of Wax at 20mm Thickness and 80°C

In Fig. 23 the obtained results show that, in old combs, the TPR decreased by increasing the angle slopes (13527.96, 14217.62, 11405.93W) for 7.5, 15.5 and 23° slope, respectively.

The same situation was observed in capping and natural wax, so the TPR were (3766.61, 5676.44, 4164.49W) and (22413.97, 31830.49, 21618.21W) for 7.5, 15.5 and 23° slope, respectively.

From these results, it was noticed that, 23 mile was the lowest of TPR because the time decreased at this slope. Also, capping has lower TPR than the others two types due to decrease the time needed to sort the beeswax. (*i.e.* capping has big size of impurities)

Comparing Between the Systems Development

Effect of Different Extraction Ways (S, SEH and SEHF) on Production Rate for Using Different Kinds of Wax at 23° Slope, 80 °C and at 20mm Thickness

Comparing the three developmental systems for wax extraction production rate, the result showed that, in old combs SEH had more production rate (49.02 g/hr) than SEHF (34.82 g/hr) and S (23.94g/hr). Also, in capping the production rate of SEH (892.61g/hr) more than the other two types. The same situation was present in natural beeswax as shown in Fig. 24. So, it was noticed that, capping in SEH was the best in the rate of wax production. This because SEH system had two source of heat one from the sun light above the extractor and the other was heater inside the system so, these two sources accelerate the sorting processed reduced the time needed while SEHF system has fan which reduced temp. So the wax need more time than SEH. In S, there was one source of heat (sunlight) which consider non constant heat source, so the wax need more time to complete sort. Also, capping had more production rate due to the bigger size of its impurities so it takes less time to sort than sun light alone and SEHF in which the fan reduced the temperature so the wax need more time to sort.

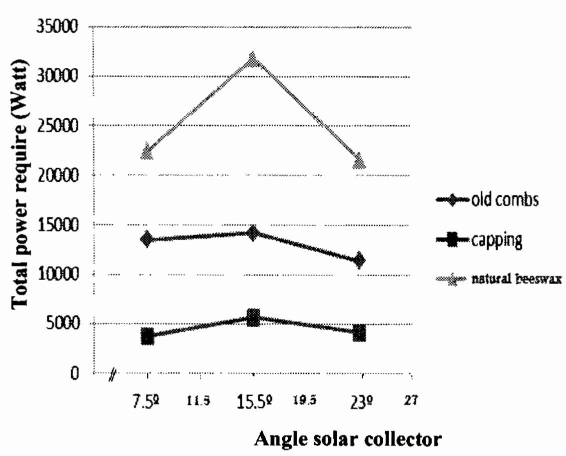


Fig. 23. Effect of angle solar collector on total power require (TPR) for developed extractor (SEHF) using different kinds of wax at 20mm and 80°C

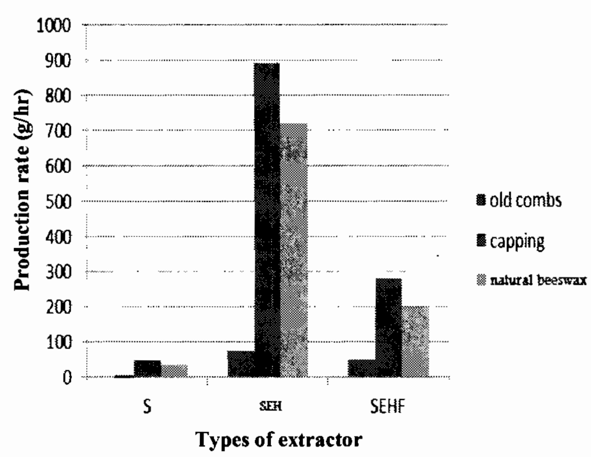


Fig. 24. Effect of different extraction ways (S, SEH and SEHF) on Production rate for using different kinds of wax at 80°C and 20mm thickness and 23° slope

Effect of Different Extraction Ways (S, SEH and SEHF) on Efficiency for Using Different Kinds of Wax at 23° slope, at 80°C and 20mm Thickness

Efficiency of different extraction ways (S& SEH and SEHF) on efficiency is presented in Fig. 25. Concerning old combs, the effect of SEH had higher result (6.79%) than S (0.62%) and SEHF (6.48%). Also, capping of natural (49.07, 72.53%), respectively. in SEH higher than S and SEHF. From these results, it was noticed that natural wax more efficiency in SEH system than old combs and capping, this due to its small impurities which can pass easily through the wax. This because SEH system had two sources of heat, one from the sun light above the extractor and the other in the heater inside the system. So, these two sources accelerated the sorting processes reducing the time needed while SEHF system has fan which reduced temp. So the wax need more time than SEH. In S, there was one source of heat (sunlight) which consider non constant heat source, so the wax need more time to complete sort, while fan caused decreased in the percentage of efficiency SEH and the lowest one is S.

Effect of Different Extraction Ways (S, SHE and SEHF) on total Power Require For Using Different Kinds of Wax at 23° slope, at 80 °C and 20mm Thickness

In Fig. 26 showed that the effect of different three ways of extraction (S, SEH, SEHF) and TPR using different kinds of wax Obtained results demonstrated that, in old combs, S wasn't had any power require because it depended on natural heat source only (sun). Whereas SEHF (11405.93W) had higher total power require than SHE (8386.59W) this because SEHF need high total power requires working electric heater in addition to fan. Also fan reduced the temperature than SHE, so the wax needs more time to sort and the total power require increase. Capping and natural had the same situation.

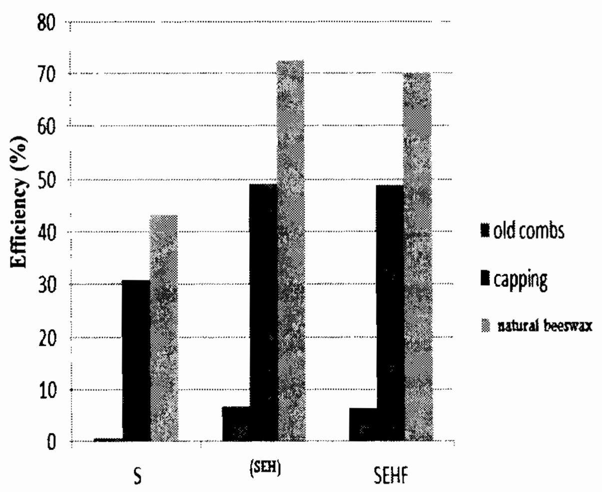


Fig. 25. Effect of different extraction ways (S, SEH and SEHF) on efficiency for using different kinds of wax at 80°C, 20mm thickness and 23° slope

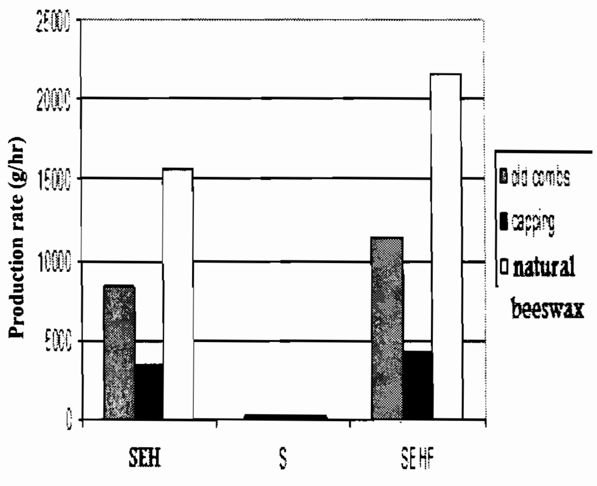


Fig. 26. Effect of different extraction ways (S, SEH and SEHF) on total power require (TPR) for using different kinds of wax at 80°C, 20mm thickness and 23° slope

Natural Properties

The Percentages of Paraffin Wax

In Fig. 27 which demonstrated the percentages of paraffin wax, ES has 0% paraffin while PB has 100% paraffin, this become ES contains bees wax only while PB contains petroleum substances only, so, the two differ from each other in all natural properties. In sample before treatment, we found that, (O, N, C), respectively, this become old comb contains. Comb foundation made from paraffin wax, while N,C contain large amount of beeswax, and as a result of the effect of heat putting in water for washing the samples, the percentage, of paraffin wax decreased until reach 6-2% in all systems, Also, N, C decreased after treatment than before treatment and reached 1%.

The Percentages of Impurities

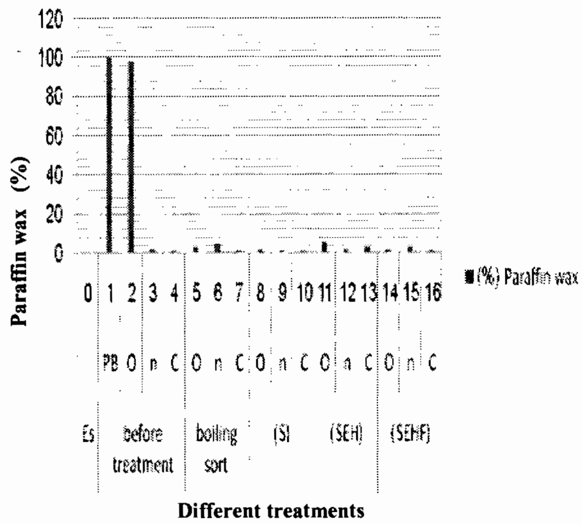
All samples were analyzed to demonstre the percentages of impurities (Fig. 28). This histogram showed that there were great different between this percentage greatly increased in samples before treatment for O, N. C (43, 26, 36) than after treatment for all sorting systems. This due to the net using through sorting but the percentage greatly increased than ES and PB. In contrast to the developmental system which the percentages of impurities decreased. This deceasing reached 0.001 and nearly to ES. This become in developmental system used with different pore sizes and angle mile. While in boiling system, comparing between samples before and after treatment reflected that the percentages of impurities before treatment decreased than after treatment but increased than samples produced from developmental system due to use one kind of net in all types of wax.

The Percentages of Humidity

All samples were analyzes before and after treatment to determine the percentage of humidity. The percentage of humidity was high in O, N, C (10, 13, 21) before treatment, due to washing the wax before treatment which increased the humidity inside it. In addition the percentages of humidity in O, N, C in developmental system (S, SHE, SEHF) were (0.3, 0.3, 0.2), (0.3, 0.3, 0.4) and (0.2, 0.2, 0.1), respectively. It was noticed that, all these results nearly to the percentages of humidity in ES (5%) similarly to PB (0.3). This because after washing wax, it be sort using dry heating source. So the humidity decreases and the problems which estimated from humidity also decreased, as shown in Fig. 29.

The Flexibility of Degree

From Fig. 30, which demonstrated the flexibility degree of beeswax among different treatments, it was noticed that, there was difference between the degree of flexibility of ES (60) and PB (*i.e.,* which made comb foundation), the degree of PB wax 38, so the difference between the two about 22 this because PB wax extracting petroleum substances which has natural properties difference from beeswax which extracting from bees. According to (O) sample after treatment the degree of flexibility was 39 and in SEH and SEHF were 39 and 38, respectively. This because O wax consider mixture of PB and beeswax. So, it produces new properties different from PB and beeswax alone. The degree of flexibility increased in N and C than PB in all systems such as S, SEH, SEHF (41, 42), (41, 41), (41, 41), respectively. but decreased than ES this because we need high degree of temperature in sorting of wax in all systems which reached to 80 in developmental system these highly than the degree of wax melting (64 – 69), so it affected the flexibility degree because high degree of temp., cause evaporation of oils (Abdelslam, 1968). The results of O, N, C before treatment were (43, 41 and 42) respectively. These samples contains different kinds of impurities, wax and water which affected the flexibility degree and decreased than ES.



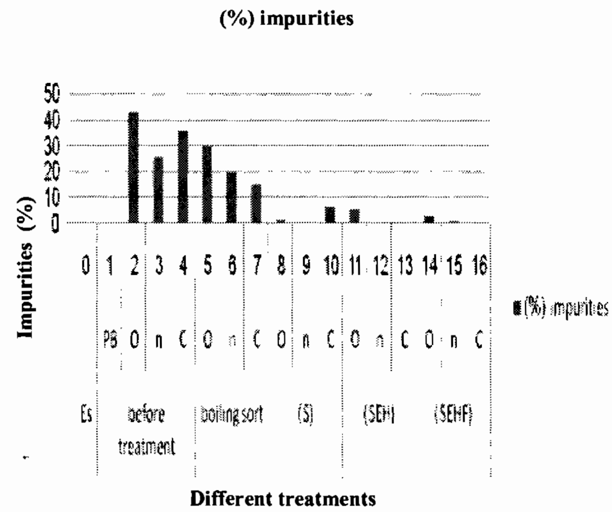
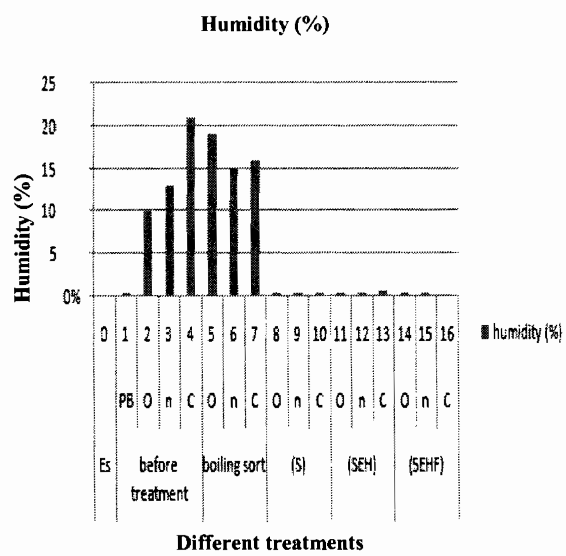


Fig. 27. The percentages of paraffin wax in different samples of bees wax

ES (Egyptian standards).
S (solar energy)
SHE (using solar energy and electric heater)
SEHF (using solar energy, electric heater and fan)

Fig. 28. The percentages of impurities in different samples of bees wax

PB (comp foundation before inside the hive)
O (old combs)
n (natural wax)
C (capping)



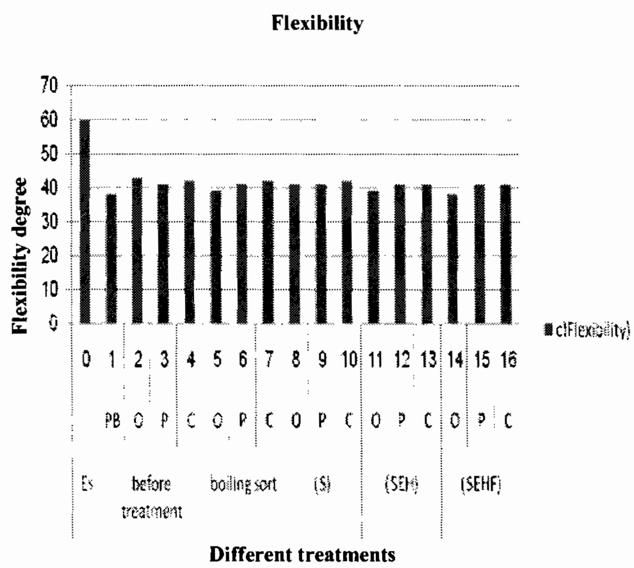


Fig. 29. The percentages of humility in different samples of bees wax

ES (Egyptian standards)
S (solar energy)
SEH (using solar energy and electric heater)
SEHF (using solar energy, electric heater and fan)

Fig. 30. The flexibility degree in different samples of bees wax

PB (comp foundation before inside the hive)
O (old combs)
n (natural wax)

C (capping)

The Melting Degree

Fig. 31, demonstrated the melting point of different samples before and after treatment. We noticed that, there were great different in the melting point of ES (64) and PB (45) this because each of them has different natural properties. The melting point of the samples before treatment different than that of ES and PB this became O, N, C wax (61.3, 60.8, 63.2), respectively, have amount of impurities with different kinds which affected the melting point. Also, there was waxy substance and water lead to melting point different than ES and PB. The C and N after treatment in developmental system SHE and SEHF (60.7 and 60.3) and (60.4 and 59.0) respectively, slightly decreased than ES but increased than PB this due to increase the percentage of beeswax in it, so it has nearly to the properties of beeswax. But (O) wax in developmental (SEH, SEHF) System (53, 1), (58.2) and (56.1) respectively, increased than PB. While decreased than C, N in same systems. This due to decrease the beeswax percentage. In (S) system, we noticed that O, N and C (62.1, 62.5 and 63.8) respectively, this because that the developmental systems use temperature degree 80 or more which caused changing in the properties of wax.

While in (S) system, we used sunlight only which caused thermal stacking the wax sorting at low temperature. Not increased than 70. (*i.e.,* the melting point in this system nearly to the melting point of beeswax which was about (64-69).

The Density g/m³

Fig. 32 demonstrated the density of all samples. From this histogram, we noticed that, there was nearly in density between ES(0.96) and C and N in boiling SEH and SEHF systems which were (0.927, 0, 917), (0.920,0.909) and (0, 955, 0.953) respectively, but PB (0.886) and O in SHE and SEHF (0.864, 0.897) and also S for O, N and C (0.877, 0.894 and 0.883) respectively, This because PB made from wax paraffin which has different natural properties than ES and so, different density. In samples (O,C and N) before treatment (0.914, 0.805 and 0,768) we noticed that these was different in density than ES this due to the present of different kinds of impurities and water mixed with wax which affected the density of sample of the same kind before treatment.

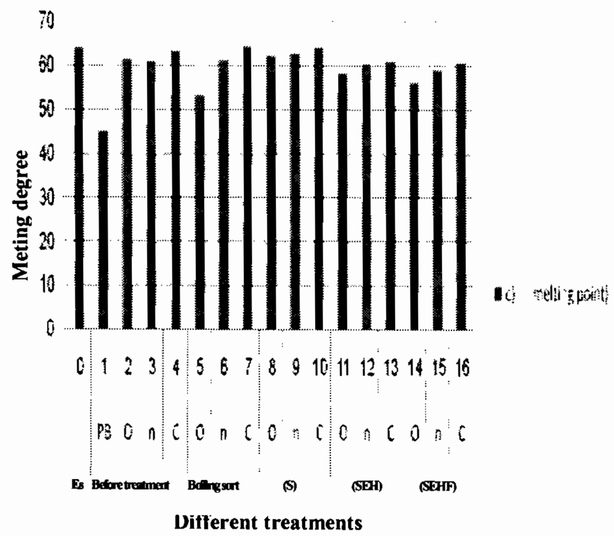


Fig. 31. The melting degree in different samples of bees wax

ES (Egyptian standards)
S (solar energy),
SEH (using solar energy and electric heater),
SEHF (using solar energy, electric heater and fan)

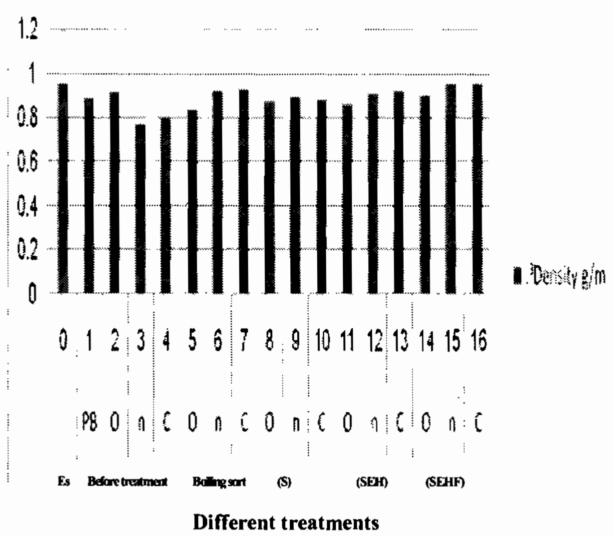


Fig. 32. The density in different samples of bees wax

PB (comp foundation before inside the hive)
(old combs).
n (natural wax),C (capping)

Conclusions

The present study recommended that using developmental systems (SEH) in fields which need high quality of beeswax and this at 80ºC, 23º solar collector angle, and sample thickness more than 20mm which give more productivity, less losses percentage although it needs more energy. It also may be used in small apiaries.

REFERENCES

Abdelslam, A. (1968). Beekeeping. Publishing House Anglo-Egyptian library, 233-261.

Dizaji, A.A., H.M. Alishah, A.A. Shaddel and N.M. Sis (2008). Effects of comb wax age on the brood and honey product performance in honey bee. Asian J. Anim. and Vet. Adv., 3(1): 51-53

Egyptian organization for standardization and quality Arab republic of Egypt (2005). Bees product beeswax, 67 (100): 30.

Kaasm, A., M. Abd El-latif, M. El-Shazly, A. Kashta and A. Basyone (2006). Solar Thermal Systems. Hourly total solar radiation flux incident on a horizontal title and vertical surfaces. Dar al iman printing. The First edition, 100-120.

Kaye, G.W. and T.H. Laby (2013)."Mechanical properties of materials". Kaye and Laby Tables of Physical and Chemical Constants. National Physical Laboratory. Retrieved 25.

Khetaby, A.M. (1981). Influence of brood cells size on honey bees. M.Sc. Thesis. Plant Protection Dept., Fac. Agric., Zagazig Univ., Egypt, 1-7.

Nathan S.L. (2007). Toward cost-effective solar energy use. Beckman Institute and kavli nanoscience institute, 210 Noyes Laboratory, 127-72, California Institute of Technology, Pasadena.

Seeley, T.D., A.M. Reich and J. Tautz (2005). Does plastic comb foundation hinder waggle dance communication, Apidologie, 36 (4): 513-521.

Shayne, R and N. Umney (2003). Conservation of furniture. Butterworth-Heinemann, 164.

Soteris, A.K. (2004). Solar thermal collectors and applications. Department of Mechanical Engineering, Higher Technical Institute, P.O. Box 20423, Nicosia 2152, Cyprus

Toledo, V de A.A. De and R.H. Nogueira-Couto (1995). The wax yield obtained from new and old combs and caps of Apis mellifera hives by means of various extractors. Apiacta., 30 (3/4): 65-68.

Yoshida, Y. and T. Yoshida (1991). Response of honey bees to comb foundation and artificial queen cell cups made of various waxes. Honeybee Sci., 12 (1): 31-33.

تصنيـــع وتقييـــم أداء فـــراز شـــــمع النحـــل للإنتــــاج المحلـــــــــى

سماح السيد أحمد المسلمى[1] - محمد سعد الدين الشال[1] - أحمد فؤاد عبدالمطلب غنيم[2]

١- قسم الهندسة الزراعية - كلية الزراعة - جامعة الزقازيق - مصر

٢- معهد بحوث الهندسة الزراعية - مركز البحوث الزراعية - الجيزة - مصر

استخدم شمع العسل قديما فى جميع المجالات حتى تم اكتشاف الشموع النباتية والحيوانية والمعدنية فقلت قيمته التجارية حتى عام ١٨٥٧ م عندما اخترع العالم لانجستروث (Langstroth) الخلية الحديثة ذات الإطارات المتحركة لزيادة نقاء العسل ويسهل على النحال رعايته ثم أكمل العالم جوهانزمهرج (Geo Hanzmhrang) الاختراع بالوصول للأساسات الشمعية، أثر ذلك على كميه الشمع المنتجة فقلت بصوره كبيره. حاول كثيرون عمل أقراص بديله مصنوعة من الورق المقوى و بلاستيك والألمونيوم وقد فشلت هذه المحاولات فقد قرض الأقراص الأولى وماتت أعداد كبيره من الطائفة فى النوع الثانى والثالث، كما استخدم شموع أخرى غير شمع النحل ولكن رفض النحل مط هذه الأقراص كما انه يعتبر شمع مغشوش طبقا للقرار الوزارى رقم ٤٨٨ لسنه ١٩٥٨م و مواصفات القياسية المصرية بالهيئة العامة للمواصفات و الجودة لسنة ٢٠٠٥م، ومن الإحصاءات تبين أن هناك فجوه بين إنتاج مصر من الشمع حيث لوحظ أنها تنتج ٦٧١ ألف كيلو جرام شمع نحل ولكنها تحتاج إلى ٨٢٠ ألف كيلو جرام شمع ولذلك يوجد عجز قدره ١٤٩ ألف كيلو جرام لتغطية الإنتاج المحلى كما استخدم على مدى واسع فى مجالات كثيرة خاصة فى الأدوية والتصنيع الغذائى، ظهرت مشكلات هامة فى فرز الشمع حيث أن جميع الطرق المحلية تعتمد على صهر الشمع فى ماء مغلي تصل درجه حرارته إلى ١٠٠ درجة مئوية فيؤثر على جوده الشمع والخواص الطبيعية كما يؤدى إلى تصلبه وتكسره وفقدان ليونته علما بان درجة حرارة صهر الشمع ما بين ٦٣- ٦٩ درجه مئوية، وتم دراسة مجموعة من المتغيرات البحثية وكانت كالآتى: النظام المطور بثلاث طرق (استخدام الشمس المباشرة (S)، استخدام الشمس المباشرة مع سخان كهربائى (SEH) واستخدام الشمس المباشرة مع سخان كهربائى ومروحة (SEHF).عند درجة الحرارة المستخدمة (٥٠-٦٠-٧٠ -٨٠°م) وعند زاويا الميل للمجمع الشمسى المستخدم (٧,٥ - ١٥,٥- ٢٣,٥°) وعند سمك عينات لشمع النحل المستخدمة (٥- ١٠-١٥-٢٠مم)، وقد تم قياس عده مؤشرات مثل الإنتاجية، الكفاءة ، نسبة الفقد والطاقة المستخدمة بالإضافة إلى تحليل الخواص الطبيعية (الكثافة، نسبة الشوائب، درجة الليونة ، نسبة الرطوبة و نقطة الانصهار)، وكانت النتائج كالآتى: لوحظ أن أفضل النتائج من حيث زيادة الإنتاجية، الكفاءة، قلة نسبة الفقد و قلة الطاقة المستخدمة كانت عند المعاملات الآتية: درجة الحرارة ٨٠°م، زاوية ميل المجمع الشمسى ٢٣ درجة وسمك العينة ٢٠ مم، وبمقارنه الثلاثة طرق المختلفة فى النظام المطور (S, SEH,SEHF) من حيث معدل الإنتاجية كانت النتائج لأنواع (الشمع القديم ، الأغطية و الزوائد الشمعية) فى النظام S كانت (٠,٦٢ ، ٧٥,٤٥ ، ٥١,١٣ جرام / ساعة) على التوالى وفى النظام SEH كانت الإنتاجية (٤٩,٠٢ ، ٨٩٢,٦١ ، ٢٧٩,٢٤ جرام/ ساعة) للثلاث أنواع شمع على التوالى بينما كان النظام SEHF (٣٤,٨٢ ، ٧١٧,٥٠، ١٩٨,٥٨ جرام / الساعة) على التوالى، فوجد أن الطريقة SEH أفضل الطرق المستخدمة لفرز الشمع فى جميع المؤشرات الميكانيكية، عند مقارنة أفضل طريقة للفرز (SEH) أعطى أعلى إنتاجية لشمع (القديم وشمع الأغطية والزوائد) كانت (٤٩,٠٢ ، ٨٩٢,٦١ ، ٢٧٩,٢٤ جرام/ ساعة) وأفضل كفاءة (٦,٧٩، ٤٩,٠٧، ٧٢,٥٣%) للأنواع الثلاثة (قديم وأغطية وزوائد) وأقل نسبة للفقد ولكن استهلك طاقه أعلى من S. وأقل من SEHF، وجد تحسن ملحوظ فى الخواص الطبيعية باستخدام النظام المطور عن الشمع المتداول ويقترب من الشمع ذو المواصفات القياسية، وأوصت الدراسة باستخدام النظام المطور (SEH) فى فرز شمع النحل تحت الظروف المحلية عند درجة الحرارة ٨٠°م، زاوية ميل المجمع الشمسى ٢٣ درجة وسمك اكبر من ٢٠مم فى المناحل الصغيرة والمتوسطة وتطبيق ذلك على مستوى المناحل الكبيرة .

المحكمـــــون:

١- أ.د. ســـمير أحمـــد طايـــل أستاذ الهندسة الزراعية – كلية الزراعة – جامعة الأزهر.

٢- أ.د. محمد محمد مراد حسن أستاذ ورئيس قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق.