DEVEOLPMENT AND EVALUATION OF A TANGENTIAL HONEY - EXTRACTOR

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ABSTRACT

The honey extractor is an essential equipment, which any bee-keeper should have in order to extract the maximum quantity of honey from the combs. The tangential position of the combs inside the extractor is used for extracting the honey centrifugally by spinning honey out of the honeycombs after they have been uncapped. Honey is usually extracted by a manual extractor, which requires lots of effort and time. The main objectives of this study were to improve a four comb manual extractor by converting it into an electric one with a safety break unit that handles 8 combs at once in order to extract big amounts of honey in a short period of time. Some physical characteristics such as moisture content, density, and viscosity of honey collected form three kinds of plants (alfalfa, cotton and citrus) were considered in this study. The effect of wax type (artificial paraffin wax and natural beeswax) and combs thickness and mass on the extracted honey was also investigated in this study. The mean moisture contents, density and viscosity at 25 °C for honey collected form citrus, alfalfa and cotton were (18.10 , 16.98 and 14.74 %); (1.40, 1.41, 1.43 g/cm³) and (48.10, 69.03 and 137.96 poises), respectively. The mean density of the artificial paraffin wax and natural beeswax were 0.91 and 0.98 g/cm³ respectively .The mean thicknesses and mass for combs collected from (alfalfa, cotton and citrus) were (3.91, 3.79 and 3.57 cm) and (1707.46, 1640.50 and 1156.50 g), respectively. The extractor was constructed to operate manually and electrically, which can be installed and operated at home or at the farm where breeding of honey bees is possible. The evaluation included two operation modes (manual and electric); three ages of honeycombs (used for 1, 2 and 3 years); three extracting times (08.00 am, 11.00 am and 02.00 pm); and five extraction speeds [5.70, 12.56, 14.65, 17.58 and 21.98 m/s].

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It was observed that the maximum value of extracting efficiency was achieved with the electric extractor for, honeycombs used for 3 years, at 02.00 pm and at an extraction speed of 21.98 m/s. The maximum value of extracting capacity was achieved with electric extractor for, honeycombs used for 2 years; at 02.00 pm and at an extraction speed of 21.98 m/s. Minimum value of broken honeycombs was achieved with the electric extractor for the, honeycombs used for 3 years, if extracted at 08.00 am and at a speed of 12.56 m/s.

Keywords: development, evaluation, centrifugal, honey extractor, physical characteristics, honeycombs.

INTRODUCTION

Honey in this research referred to the honey produced by honey bees (*Apis mellifera*) that consider one of the best known insects. It is a natural sweet substance produced from the nectar of blossoms or from the selection of living parts of plants or excretions of plant sucking insects on the living parts of plants, which honey bees collects, transformed and combine with specific substances of their own, store and leave in the honeycomb to ripen and mature *(Breadbear, 2009)*. So it is the most important primary product of beekeeping both quantitatively and economically *(Meda et al., 2005)*. Egypt production from natural honey in 2012 was estimated to be 5,700 metric tonnes. *(Faostat, 2012)* . Honey contains a wide range of sugars, depending on the nectar source and small amounts of other substances such as minerals, vitamins, proteins and some organic acids *(Jasim et al., 2007)*. Honey is composed of simple sugars, mainly fructose, glucose, maltose and raffinose among others *(Andrew et al., 2004)*.Essentially, glucose and fructose are its major constituents *(Jeff, 2002; Nagai et al., 2002). Weaver and Weaver, (2000)* reported that honey improves food assimilation and is to be used for chronic and infective intestinal problems such as constipation, duodenal ulcers and liver disturbance. Honey can be made dried or dehydrated by various industrial techniques by including inclusion in some recipes *Sanford, (2000)*. Because of these benefits, honey extraction is very important. There is no available

documented information or data on these important physical properties of Egyptian honey for purposes processing and storage.

In the designing of honey extraction and processing equipment, these properties play a major role. 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 regarding these parameters and as a result have managed to design and fabricate extraction and processing equipment as well as setting favorable conditions for its use *(Crane, 1979; Ricciardelli, D and Albore, 1998; Terrab et al., 2004).* 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, for 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).* Different types of honey may have different densities because of water content variation. Therefore, when honeys with different specific gravity are put together in storage tanks, they show distinct stratification. The less dense honey with high moisture content, settles above the denser drier honey. This prompts more thorough mixing during processing and packing to avoid such inconvenient separation. 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).* Viscosity is the property of a fluid that resists the force tending to cause fluid flow. It is one of the most important physical and sensory characteristics of honey, which affects the quality of the product and the design of honey processing equipment. It is crucial in all process-engineering stages of production, starting from the extraction of honey from the combs, straining, mixing of different honey types, pumping, processing to packaging. Viscosity of many liquids, including honey is sensitive to temperature changes, decreasing when temperature increases. Liquids with this behavior are referred to as Newtonian liquids. From the literature, many honey varieties exhibit Newtonian flow behavior

(Sopade et al., 2003; Mossel et al., 2000). 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 *(White, 1975; Yanniotis et al., 2006).* The viscosity increases with agitation or stirring and therefore during honey processing, this important property must be taken into considerations *(FAO, 1996; Yanniotis et al., 2006).*

The honey extracted with manual extractor is sticky and inefficient and time consuming. Series of extractor have been developed in advance countries e.g. United States, Germany, Australia, Italy and other (such extractors as the tangential, the radial, the automatic programmable and the electrical driven types *(Sammataro and Alphonse, 1986).* Beekeepers from developing countries such as Egypt will not be able to buy the types mentioned above because of their costs. Therefore, there is a need to develop the local manual tangential extractor, that is made from affordable materials.

Therefore, the objectives of the present study were as follows:

a) to investigate some physical properties of honey produced from different regions in Egypt.

b) to allow data for designing and fabrication of processing equipment for Egyptian honey.

c) to develop a small manual honey extractor that is affordable by beekeeper.

d) to study and recommend the best combination of operating parameters for the developed machine that maximize the extracting efficiency (η_e., %) and extracting capacity (Ec, kg/h.) and minimized the broken honeycombs, (B_c,%) and operation cost (conseguently reduce the production cost

MATERIALS AND METHODS

1- Materials:

Bees from a private apiary at Meet-Salseel, EL- Dakahliyah, Egypt were used for nectar collection from three kinds of flowers (citrus, alfalfa and cotton). Some physical properties such as : moisture contents, density and viscosity were considered to develop and evaluate a manual tangential honey-extractor.

1-1 Physical properties:

1-1-1 Moisture content (w, %):

A 20.0 g honey sample was put in a 50 ml flask, closed tightly and then placed on water bath at 50 °C for dissolution of any sugar crystals. It was cooled to ambient temperature and a small amount (two to three drops) was put on the refractometer prism, spread evenly and refractive index determined after two minutes *(AOAC, 1990)*. The values obtained used to determined moisture content (w, %) using Wedmore Table of refractive index *(Wedmore, 1955)* based on the following equation:

$$w = \frac{1.73190 - \log(R.I. - 1)}{0.002243} \rightarrow (1)$$

where: **w** : is the water content in g per 100 g of honey and **R.I.**: is the refractive index of honey.

1-1-2 Density of honey (ρ_h, g/cm^3):

The mass (M, $_{gram}$) of honey was determined (in gram) by using an electric digital balance with an accuracy of 0.0001g. The density (ρ_h, g/cm^3) of honey was determined by using a graduated flask with a known volume. It was filled with honey samples. Its volume was estimated by filling with water. The water was then weighed and the volume was calculated by using the following equation.

$$V = \frac{M_w}{\rho_w} \rightarrow (2)$$

where **M_w** is the mass of water in g and **ρ_w** is the density of water, g/cm^3
The density of honey was calculated as the ratio of the mass and the volume of the container as follows:

$$\rho_h = \frac{m}{v} \quad , g/cm^3 \quad \rightarrow (3)$$

where: ρ_h is the density of the honey, g/cm^3, **m** is the mass of honey in g and **v** is the volume of the container in cm^3.

1-1-3 The coefficient of viscosity (η, poise):

It was measured by dropping a ball bearings (with 1.0, 1.5 and 2.0 cm radii) into a jar of honey and timing the fall between two points. The velocity of balls was calculated by using the following equation.

$$v = \frac{d}{t} \quad , cm/\sec \quad \rightarrow (4)$$

where **v** is the velocity of every ball in cm/sec, **d** is the distance between two points in cm and **t** is the time of falling in sec.

$$\eta_n = \frac{2r^2 g}{9v}(\rho_s - \rho_h) \quad \rightarrow (5)$$

Where η_n is the coefficient of viscosity for every ball (poise), ρ_s is the ball density (7.8 gm/cm^3), ρ_h is the honey density and **g** is 980 cm/s^2. By repeating the last steps with different ball diameters, we can determine the average value of coefficient of viscosity (η, poise).

$$\eta = \frac{\eta_1 + \eta_2 + \eta_3}{3} \rightarrow \quad (6)$$

Where **η 1**, **η 2** and **η 3** are the coefficients of viscosity (in poise) for balls 1, 2 and 3, respectively.

1-1-4 Density of beeswax (ρ bwax, g/cm^3) and paraffin wax (ρ pwax, g/cm^3):

To measure the density of beeswax (ρ_{bwax}, g/cm^3) and paraffin wax (ρ_{pwax}, g/cm^3), the wax samples were sized into cubes with known dimensions and weighed by using an electric digital scale with an accuracy of 0.0001g.

1-1-5 Thickness (T, cm):

To determine the average thickness (T, cm) of the combs, a sample of 100 randomly selected combs was used. The thickness was measured by caliper with an accuracy of 0.05 mm.

1-1-5 Weight of combs (M, gram):

The load should balance by spreading the weight evenly around the reel so, a digital scale was used to determine the weight of combs samples (M, gram) with an accuracy of 0.01 gram.

1-2 Machine Description:

Figures (1 and 2) illustrate the tangential extractors type (the combs sit tangent to the direction of the spinner's rotation) that is used in this study for extracting honey. It includes a central drive shaft carrying the assistant manual driving system on its top and it is provided with the electric driving system on its bottom. The cages can be turned, so we did not need to remove and replace the combs. Each frame was spun to extract honey from the outer side of the honeycomb and then it is turned to extract the rest of the honey from the other side. The whole mechanism was loaded on 4 legs and housed in a galvanized cylindrical container for honey collection and evacuation. During this process, the extractor should be kept in a horizontal position.
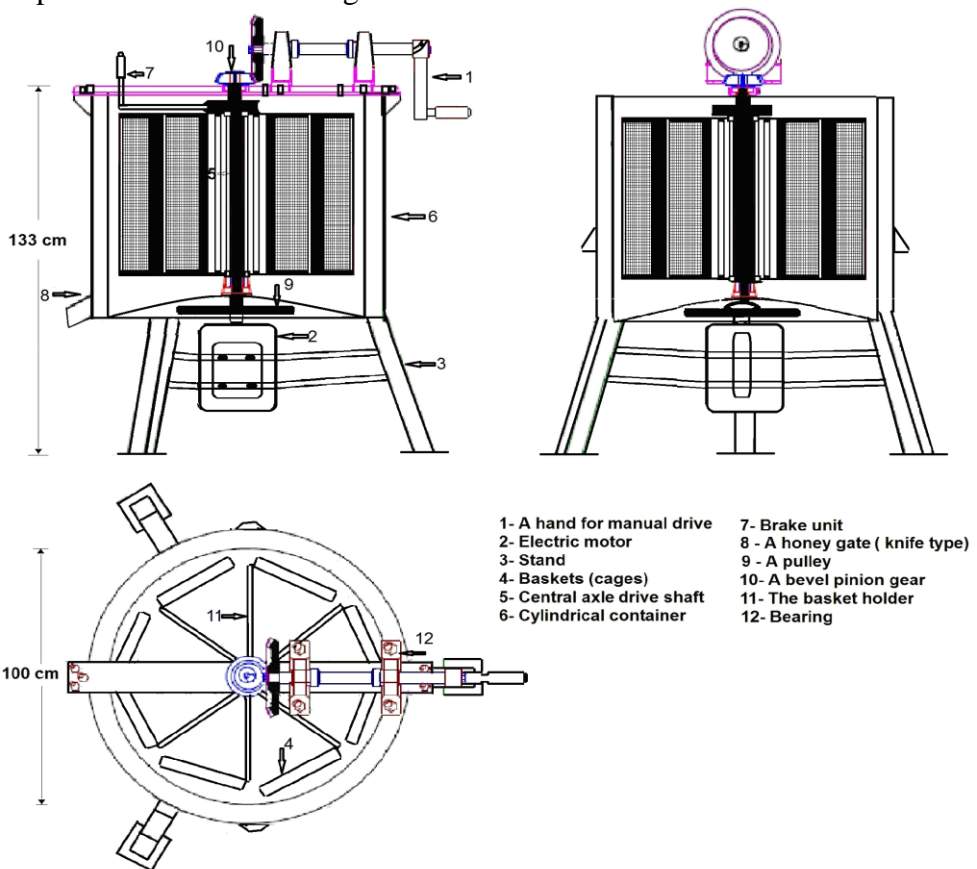
This machine consists of an extraction unit; an electric power drive unit and its transmission system; an assistant manual drive unit and a brake unit.

Figure 1: The honey extractor

The machine has a diameter of 100 cm and a height of 147 cm, and it weights 245 kg. The extraction unit can handle 8 baskets [40 cm x 20 cm x 5.5 cm, each] at once. It consisted of a central axle drive shaft, 15 mm, held by two bearings. A ball bearing was fitted at the top of the basket holder and the axle rod was passes through it. A bush bearing was fixed to the bottom of the cylindrical container. The upper surface of the bush has a socket and steel balls. The bush was raised and a seal was used on the top of the bush to avoid mixing of grease or worn out parts of steel with the honey. There were 8 bars at the upper and lower sides of the shaft for the 8 hanging wire baskets. The baskets were arranged tangent to the circular shape against the outer side of the cylindrical container.

The baskets, which hold the combs for extracting, were very simple. They have rectangular tops and bottoms. The clearance between the baskets and the cylindrical container was 50 mm. The aluminum wire-mesh should be only on the side walls to allow the honey to pass through them. Leaving the bottoms open would provide them enough structural support to securely hold the combs upright and prevent them from falling into the bottom of the tank. All baskets can be swiveled on their axis without removing them from the extractor. There was a wrapping bungee cord around the tank to force baskets back into a circular shape. The height of the cylindrical container was 93 cm . The cylindrical container has a conical bottom. The outlet was provided with a honey gate (knife type) valve (25 mm in diameter and, 50 mm in length). It is fixed in a position that enables the cylindrical container to be completely emptied with minimum tilting.

1- A hand for manual drive
2- Electric motor
3- Stand
4- Baskets (cages)
5- Central axle drive shaft
6- Cylindrical container
7- Brake unit
8 - A honey gate (knife type)
9 - A pulley
10- A bevel pinion gear
11- The basket holder
12- Bearing

Figure 2: Elevation, side view and top view of the developed extractor.

An electric motor of 0.75 kW (1 hp), 50 HZ and 380 V at rotating speed of 1400 rpm (4.4 m/s), three phase was placed under the extractor. The power is transmitted from the motor directly to a main drive shaft by means of cast iron pulleys and V-belt. The electrical motor can be moved on its base to allow adjusting the belt tension. So as the motor spins, the belt will rotate and spins the frame holder.

The electric motor has a pulley, 6 cm diameter O.D., to give the required r.p.m. of the main drive shaft. The power is transmitted from the electric motor to pulleys [20, 25, 30 and 35 cm (O.D)] fitted on the main shaft. It changes the roller speed to 240, 280, 336 and 418 r.p.m (12.56, 14.65, 17.58 and 21.98 m/s), respectively.

The assistant manual system consists of a handle made from two pieces. The first piece of the handle should pass through the holes provided in the handle support, which in turn is fixed on a steel strip (6 mm thick and 40 mm wide) running across the cylindrical container. This mild steel strip carrying the handle support should be supported by two steel brackets riveted to the cylindrical container. One end of the first piece of the handle have beveled gear, which engages with a beveled pinion supported on the top of the central shaft. The gear ratio was 1:5. The other end of the first piece of the handle is fixed to one end of the second piece of the handle. A wooden grip is provided for the other end of the second piece of handle. The handle operated sideways.

The brake unit consists of an arm assembled in a vertical position and fixed in the steel strip in one point. At the lower end of the arm there was a short steel rod ended with a half circle ring coated with rubber. When the arm attracted back the half circle ring fractioned with a pulley assembled under the beveled pinion and stopped the extractor.

1-3 Studied factors:
1-3-1 Variable factors:
1-3-1-1 Extractor type:
Two types of extractors were used. They were manual and electric named E_1 and E_2, respectively.
1-3-1-2 The age of honeycombs:
Three ages of honeycombs were used. They were used for 1, 2 and 3 years named c_1, c_2 and c_3, respectively.

1-3-1-3 Extraction time:

Three extracting times were used. They were 08.00 am, 11.00 am and 02.00 pm, which were named T_1, T_2 and T_3, respectively.

1-3-1-4 Extraction speeds:

Five levels of speeds were measured. They were 5.7, 12.56, 14.65, 17.58 and 21.98 m/s named S_1, S_2, S_3, S_4 and S_5, respectively.

1-3-2 Relatively fixed factors:

1- Power: - An electric motor of 0.75 kW (1 hp).

2- Extracting time: - 3 min.

3- Clearance between the frame and the basket about 0.8 cm from all sides.

4- Honey type: - collected from alfalfa.

2- Methods:

The experimental procedure that was carried out on the developed machine was extracting efficiency, honeycombs breakage and extracting capacity.

2-1 Machine unit measurements:

For preparing the machine for operation the clearances should be sufficient to minimize honeycombs damage and facilitate frame loading. Four clearance (2.5, 1.0, 0.8 and 0.5 cm) were studied. Initially and the results indicated that when the clearance was too high, the honeycombs was damaged, and when it was too small, the loading of combs was very difficult, so the optimum clearance with minimum damage and easy loading was 0.8 cm.

The electric motor has to be moved to be able to match the different pulley diameters (20, 25, 30 and 35 cm) on the main shaft and consequently change the drum speed (240, 280, 363 and 418 r.p.m) respectively.

The speeds of rotation of the main axial shafts were measured by laser optical tachometer device with range of 1:99.999 rev/min and accuracy of + (0.05 % + 1 digits).

2-2 Extracting processes:-

First the honeycombs areextracted from the beehives. The next step is to uncap the honey combs. The wax cappings are sliced off by a sharp long knife or special knives heated by steam or electricity or by capping scratchers (***Jeff Rounce, 2002)***. After the honey is uncapped, it is put into honey extractor that should be kept in horizontal position during process. The load should be balanced by spreading the weight evenly around the reel. If it is unbalanced, the

extractor will vibrate too much when the reel rotates and the honey may not be extracted completely. Each frame was handled four times, load, turn, turn, unload and the machine has to be started and stopped four times. The honey is extracted by spinning it out of the honeycombs to the cylindrical container wall and then it flows by gravity into the lower. The frame was only handled twice as it should be emptied on one side then turned and emptied on the other side. When the extraction is complete, we should turn the switch "off". The basket keeps rotating by force of inertia, so should not be braked suddenly. The honey was moved into the base of the extractor. Once the level of the honey reaches the level of the spinner, we must stop and open the gate. When using the extractor, we placed a bucket under the extractor's open honey gate to continually drain the honey. The wax is separated from the honey by filtering through a sieve or by pressing. At the end of process, the combs are removed and put back into the bee hives so that the bees can fill them with honey in the next season.

The experiments were carried out on one species of honey-bee (Apis mellifera carnica). The tests were carried out at the periods from 20-30 April , 1-10 June and 1-10 September to study the effect of the modified extracting machine upon the extracting efficiency, honeycombs damage and extracting capacity (productivity) as affected by extractor types (manual and electric) named E_1 and E_2, respectively; honeycombs conditions (used for 1, 2 and 3 years), named C_1, C_2 and C_3, respectively; extracting times (08.00 am, 11.00 am and 02.00 pm), named T_1, T_2 and T_3, respectively and extraction speeds (5.7, 12.56, 14.65, 17.58 and 21.98 m/s), called S_1, S_2, S_3, S_4, and S_5, respectively. Three readings (replicates) were taken and all values were recorded.

2-3 Measurements and calculations:-

 To determine the optimum conditions for the honey extracting under study, the following calibration criteria were studied: -

1- Extracting efficiency, (η_e),%.　　　2- Broken honeycombs, (Bc) ,%.
3- Extracting capacity (Ec), kg/h.

The extracting efficiency (η_e), % was determined according the following relation:-

$$\eta_e = \frac{W_{out}}{W_{max}} \times 100 \quad \rightarrow (7)$$

Where:-

W_{out} = Weight of extracted honey, kg.

$W_{max.}$ = Maximum weight of extracted honey, kg.

The broken honeycombs (B_c), % was determined according to the following relation:-

$$B_c = \frac{N_b}{N_{in}} \times 100 \quad \rightarrow (8)$$

Where:-

N_b = Number of broken combs.

N_{in} = Number of fed combs.

The productivity of the machine was determined with the help of a digital stopwatch of 0.1-sec. accuracy and an electrical scale of (0.01g) accuracy. Machine productivity was calculated as follows:-

$$P = \frac{W_{out}}{t}, kg/h...........(9)$$

Where:

t = time of test duration (hr.).

2-4 Statistical analysis:-

All obtained data was presented in figures and was analyzed statistically by using a computer program (**Minitab Release 15**) for estimating the probability at levels 1 and 5%. The graphs were drawn using the Microsoft excel window 2007.

RESULTS AND DISCUSSION

Data illustrated in figures. (3 and 4) show the comparative magnitude of mean percentage values of some physical characteristics [moisture content (w, %), density (ρ_h, $g/cm3$) and the coefficient of viscosity (η, $poise$)]of honey collected form three kinds of plants (alfalfa, cotton and citrus). The density of artificial paraffin wax(ρ_{pwax}, g/cm^3) and natural beeswax(ρ_{bwax}, g/cm^3). Combs thickness (T, cm) and mass (M, $gram$) for honey collected form (alfalfa, cotton and citrus) were.

Considerations due to the results on studied physical properties:

The refractive index was measured for the honey samples and the values obtained were used to determined moisture content (using Wedmore

table of refractive index). Wedmore table uses the relationship given in equation 1 (**Wedmore, 1955**) of moisture content and refractive index. The results of the refractive index of honey collected form citrus, alfalfa and cotton were 1.49125 ± 0.00095 (varying from 1.490 to 1.493); 1.49408 ± 0.00087 (varying from 1.4930 to 1.4961); and 1.49981 ± 0.000988 (varying from 1.4987 to 1.5018), respectively. The mean moisture contents,% at 25 °C for honey collected form citrus, alfalfa and cotton were 18.1 ± 0.38 % (varying from 17.4 - 18.6 %); 16.98 ± 0.33 % (varying from 16.2 - 17.4 %); and 14.74 ± 0.42 % (varying from 14.0 - 15.2 %), respectively. The lower moisture content was achieved with cotton honey, due to the low humidity during September month. It was remarked that the moisture content (w), %, decreased with honey source, according to the following descending order [citrus <alfalfa <cotton].

The mean density at 25 °C for honey collected form citrus, alfalfa and cotton were 1.4 ± 0.006 g/cm^3 (varying from 1.39 - 1.41 g/cm^3); 1.41 ± 0.012 g/cm^3 (varying from 1.39 -1.42 g/cm^3); and 1.43 ± 0.012 g/cm^3 (varying from 1.41 - 1.45 g/cm^3), respectively. It was remarked that (ρ_h), g/cm^3 increases as the moisture content decreases, according to the following descending order [citrus <alfalfa <cotton].

The mean coefficient of viscosity at 25 °C for honey collected form citrus, alfalfa and cotton were 48.1 ± 0.397 poises (varying from 47.5-48.9 poises); 69.03 ± 0.727 poises (varying from 68-70 poises); and 137.96 ± 0.450 poises (varying from 137-138.7 poises, respectively. It was noticed that η, poises, increased as the moisture content decreased, according to the following descending order [citrus <alfalfa <cotton].
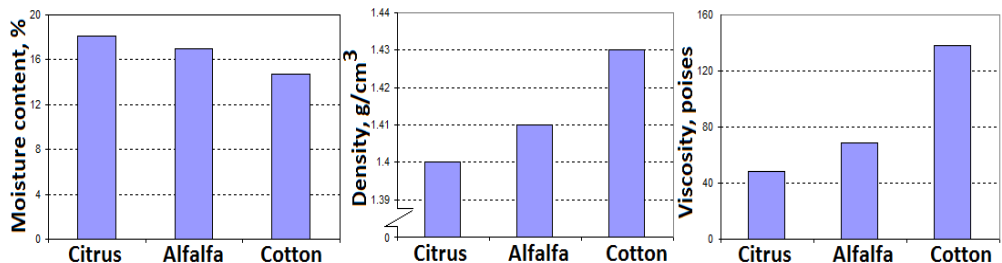
Figure 3: Effect of honey source on moisture content, g/100g; density, g/cm^3; and the coefficient of viscosity, poise.

The mean density of artificial paraffin wax and natural beeswax (figure 4) were 0.91 ± 0.031 g/cm^3 varying from $0.85 - 0.97$ g/cm^3 and 0.98 ± 0.013 g/cm^3 varying from $0.955 - 0.998$ g/cm^3 respectively. It was remarked that (ρ_w), g/cm^3 increased with wax source, according to the following descending order [artificial paraffin wax < natural beeswax].

The mean thickness (figure 4) for combs of honey collected form citrus, alfalfa and cotton were 3.57 ± 0.82 cm varying from $2.3 - 4.7$ cm; 3.91 ± 1.07 cm varying from $2.7 - 5.4$ cm; and 3.79 ± 0.86 cm varying from $2.5 - 5.1$ cm respectively. The mean mass (figure 4) for combs of honey collected form citrus, alfalfa and cotton were 1156.5 ± 398.93 gram (varying from $491-1789$ gram); 1707.46 ± 499.59 gram (varying from $934-2606$ g); and 1640.5 ± 563.24 gram (varying from $673-2463$ g), respectively. Higher thicknesses and masses were achieved with alfalfa honey, due to the moderate weather during the period from 25 May to 10 June and the big flowering area of Alfalfa. It was noticed that (T), cm, and (M), g, increased with honey source, according to the following descending order [citrus < cotton < alfalfa].
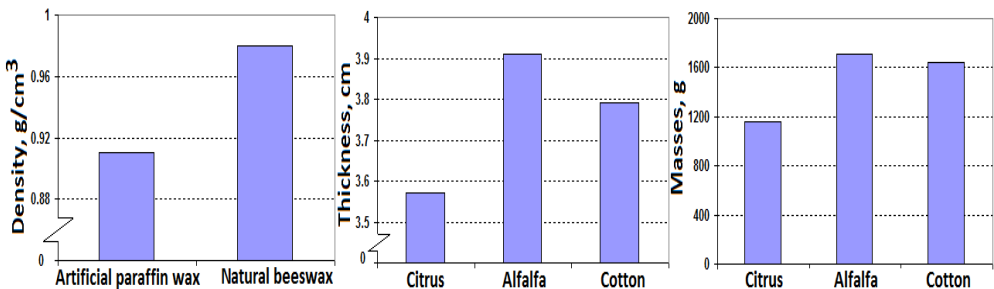
Figure 4: Effect of wax types on density, g/cm^3; and honey types on thickness, cm and masses, gram of combs.

Data illustrated in figures (5 to 7) show the comparative magnitude of mean percentage values of extracting efficiency (ηe., %), broken honeycombs, (Bc,%) and extracting capacity (Ec, kg/h.)

Effect of extractor type on (ηe., %), (Bc,%) and (Ec, kg/h.) :

The (ηe, %); (Bc, %) and (Ec, kg/h) were calculated according to equation7, 8 and 9 respectively. Figure 5 showed the effect of extractor

type on (ηe, %) ; (Bc, %) and (Ec, kg/h). Results after 3 second of extracting honey (Alfalfa) show that the mean (ηe, %) increases from 54.54% with manual extractor to 88.24 % with electric one due to the high steady velocity. The less mean (Bc, %) was 1.85 % with electric due to the less sudden motion with the electric driven. The maximum mean (Ec, kg/h) was 92.72 kg/h, which was achieved with the electric extractor due to the higher centrifugal force that extracted a maximum amount of honey from the hexagonal wax cells It was remarked that (ηe, %,) and (Ec, kg/h,) increased and (Bc, %) decreased ; with extractor type, according to the following descending order [manual < electric].
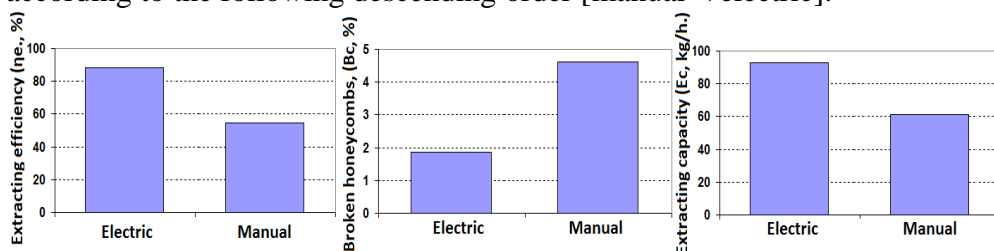
Figure 5: Effect of extractor type on extracting efficiency (ηe., %), broken honeycombs, (Bc,%) and extracting capacity (Ec, kg/h.)

Effect of honeycombs age on (ηe., %), (Bc,%) and (Ec, kg/h.):

The mean (ηe value, figure 6) increased from 69.22 % (when using honeycombs for 1 year) to 74.03 % (when using honeycombs for 3 years) because bees make hexagonal wax cell walls strong during every process of alienation so a less deterioration occurred while scraping with the serrated sharp knife in untapped process. The mean (Ec, kg/h) decreases from 82.46 kg/h when using honeycombs for 2 year to74.95 kg/h when using honeycombs for 3 years, due to the smaller size of hexagonal cells from year to year that produce small and weak workers. The lower mean (Bc = 1.99 %) was achieved when using honeycombs used for 3 year, due to the its hardness. It was noticed that (ηe, %) and (Bc, %) decreased; with honeycombs age, according to the following descending order [1 year <2 year < 3 year] but the (Ec, kg/h) increased with honeycombs age, according to the following descending order [1 year < 3 year < 2 year].
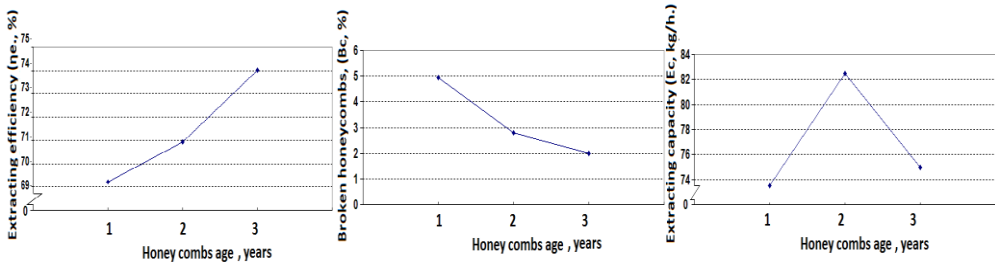
Figure 6: Effect of honeycombs age on extracting efficiency (ηe., %) %), broken honeycombs, (Bc,%) and extracting capacity (Ec, kg/h.)

Effect of extracting time on (ηe., %), (Bc,%) and (Ec, kg/h.):

The mean ηe,%, increased from 64.14% in the morning (8.00 am) to 78.36% in the afternoon (2.00 pm), due to the less viscosity of honey in the afternoon (2.00 pm), figure 7. The Bc, %, increased also by increasing temperature in the afternoon. The minimum mean (Bc, %,) was about 1.95% in the morning (8.00 am). Generally Bc, %, increased due to wax melting at the higher temperature. The mean Ec, kg/h., increased from 64.08 kg/h. (at 8.00 am) to 90.33 kg/h. (at 2.00 pm), due to the higher ambient temperature and the less viscosity of the honey in the afternoon. It was noticed that ηe (%), Bc (%) and Ec (kg/h) increased with increasing the extraction time of day, according to the following descending order 8.00 am <11.00 am <2.00 pm.
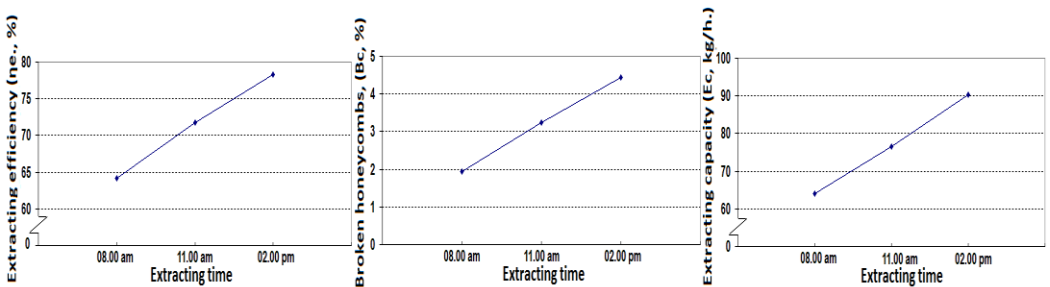
Figure7: Effect of extraction time on extracting efficiency (ηe., %) %), broken honeycombs, (Bc,%) and extracting capacity (Ec, kg/h.)

Effect of extraction speeds, r.p.m on (ηe., %), (Bc,%) and (Ec, kg/h.):
When increasing the electric extractor speeds from 5.7 to 21.98 m/s, the mean ηe (%) increased from 54.54 to 96.3% due to the increase in Centrifugal force (figure 8). The highest mean percentage of Bc (%) was

4.63 % at 5.7 m/s, due to the excessive vibration in the extracting unit with the manual extractor. The mean percentage of Bc (%) was decreased to 0.81 % at 12.56 m/s with the electric extractor and started to increase by increasing extraction speed from 12.56 to 21.98 m/s . The maximum mean Ec (kg/h) was 102.56 kg/h, which was achieved at 21.98 m/s due to the high centrifugal force that resulted in extracting all the honey located in hexagonal cells. It was noticed that ηe (%), Ec (kg/h) increased with the extractor speeds in descending order (S1< S2< S3< S4< S5). However, the Bc (%) decreased with extractor speeds, according to the following descending order (S1< S5< S4< S3< S2).
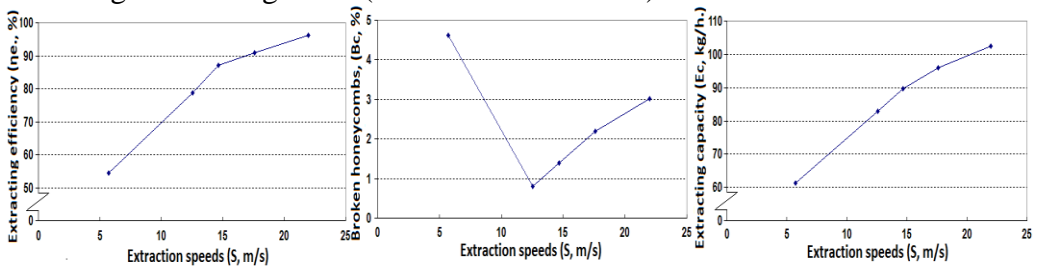

Figure 8: Effect of extraction speeds, m/s on extracting efficiency (ηe., %) %), broken honeycombs, (Bc,%) and extracting capacity (Ec, kg/h.)

Table 1: ANOVA Analysis

Changeable factor	Measurements		
	The extracting efficiency (ηe), %	The broken honeycombs (Bc), %	The extracting capacity (Ec), kg/h.
The age of honeycombs, (C)	ns	**	ns
Extraction time, (T)	**	**	**
Extraction speeds, (S)	**	ns	**
C, T and S	**	**	**
C and T	*	**	**
T and S	**	**	**
C and S	**	**	**

**, highly significant at 1% level; *, significant at 5% level; ns, non significant

CONCLUSIONS

The honey collected form cotton has the lowest percentage of moisture content; and the highest density and viscosity. The natural beeswax has the highest density. The highest yield was for honey collected form alfalfa. It was observed that the maximum values of extracting efficiency and extracting capacity were achieved with electric extractor; honeycombs used for 3 years; in the afternoon 02.00 pm or in a hot room to lower the viscosity of the honey and extraction speed 21.98 m/s. The maximum values of extracting capacity were achieved with electric extractor; honeycombs used for 2 years; in the afternoon 02.00 pm and extraction speed 21.98 m/s. Minimum value of broken honeycombs was achieved with electric extractor; honeycombs used for 3 years; at 08.00 am and extraction speed 12.56 m/s.

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الملخص العربى

تطوير وتقيم فراز العسل المماسي

محمد علي إبراهيم الراجحي * أحمد محمد أحمد الشيخة **

يعتبر فراز العسل من المعدات الأساسية التي يجب أن يمتلكها النحال من اجل استخراج اكبر كمية من العسل ويعتبر الوضع المماسي للبراويز داخل الفراز والذي يستخرج العسل بالطرد المركزي بعد إزالة الطبقة الرقيقة من الشمع التي يختم بها النحل عيون العسل من أفضل الأوضاع . وفي العادة يتم استخراج العسل بواسطة الفراز اليدوي والذي يحتاج لمزيد من الجهد والوقت لذا كان الهدف من الدراسة العمل علي تطوير فراز العسل الصغير الحجم المكون من ٤ براويز إلي أخر ٨ براويز يعمل بالكهرباء ومزود بوحدة إيقاف أمنه علي العامل مما يعمل علي

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استخرج اكبر كمية من العسل في مدة زمنية اقل. وقد تمت بعض الدراسات المسبقة علي اغلب أنواع العسل الموجدة بمصر وهي عسل الموالح والبرسيم والقطن . وكذلك تحديد كثافة الشمع المستخدم والذي قد يتم تصنيعه أو الحصول عليه من البيئة الطبيعية بواسطة النحل. كذلك تم تحديد كلا من سمك ووزن براويز العسل التي سيتم وضعها بالفراز. لأنواع العسل الثلاثة السابق ذكرها. وكانت النتائج كالتالي. متوسط رطوبة العسل هي ١٨,١ - ١٦,٩٨ - ١٤,٧٤ % وكثافته هي ١,٤ - ١,٤١ - ١,٤٣ جم/ سم³ ومعامل لزوجته ٤٨ ,١ - ٦٩ ,٠٣ – ١٣٧,٩٦ , بواز لعسل الموالح ثم البرسيم ثم القطن علي الترتيب. متوسط كثافة الشمع الصناعي هي ٠,٩١ جم /سم٣ والطبيعي هي ٠,٩٨ جم /سم³. ومتوسط سمك البراويز هي ٩١و٣- ٣,٥٧- ٣,٧٩سم وكتلتها هي ١٧٠٧,٤٦ - ١٦٤٠,٥- ١١٥٦,٥ جرام لعسل البرسيم ثم القطن ثم الموالح علي الترتيب. أما بالنسبة للفراز فقد تم تجهيزه للعمل يدويا أو بالكهرباء وذالك ليناسب العمل بالمنزل آو الحقل حيث يربي النحل وتم التقييم لكلا النوعيين اليدوي والكهربائي عند ٣ أعمار لشمع العسل هي ١ -٢-٣ أعوام و٣ مواعيد للفرز وهي ٨ صباحا و١١ صباحا و٢ مساءا وخمس سرعات للفرز هي ٥,٧ – ١٢,٥٦- ١٤,٦٥- ١٧,٥٨ – ٢١,٩٨ م /ثانية ولوحظ أن اعلي قيمة لكفاءة الاستخراج تحققت عند استعمال الفراز الكهربي مع الأقراص المستعملة لمدة ثلاث أعوام وعند الساعة الثانية بعد الظهر وعند سرعه ٢١,٩٨ م /ثانية أعلي قيمة لسعة الاستخراج تحققت عند استعمال الفراز الكهربي مع الأقراص المستعملة لمدة عامين وعند الساعة الثانية بعد الظهر وعند سرعه ٢١,٩٨ م /ثانية واقل نسبة كسر تحققت عند استعمال الفراز الكهربي والأقراص المستعملة لثلاث أعوام وعند الفرز في ٨ صباحا ومع سرعة فرز ١٢,٥٦ متر / ثانية.