Design, construction, and performance evaluation of a honey extracting machine

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Abstract: One of the major factors affecting honey quality is the method adopted in its extraction from the honeycomb. Most developing countries, particularly African countries lack appropriate equipment for honey extraction, and this affects their honey export potential. This research aims to fabricate honey extractor using locally available materials. The study is conducted from design to fabrication and experiment to determine the performance evaluation of a honey extractor in comparison with the traditionally extracted method. The physiochemical properties of the extracted honey are determined to ascertain its quality against an international standard. The volume of the extraction chamber is 55,125 cm^3 and has an extraction rate and efficiency of 69.0 $kghr^{-1}$ and 86.3 %, respectively. These figures are significantly higher (p<0.05) than 6.40 kg hr^{-1} and 59.1 % for the traditional method of honey extraction. The physicochemical analysis carried out showed that the properties of the honey extracted using the designed machine are more desirable compared with the honey extracted using the traditional method. The properties are also within the international standard except for electrical conductivity and ash content. The moisture content, electrical conductivity, ash content, free acidity, insoluble matter, hydroxymethylfurfural (HMF), glucose, fructose, sucrose and diastase number for the honey extracted using the honey extractor are 18.8 %, 1.466 mS cm^{-1}, 0.762 %, 38.77 $meqkg^{-1}$, 0.0378 g 100 g^{-1}, 42.9 mg kg^{-1}, 39.629 g 100 g^{-1}, 36.830 g 100 g^{-1}, 1.339 g 100 g^{-1} and 40.0, respectively. The availability of this designed and fabricated honey extracting machine will expand honey production, increase honey market supply, reduce honey farmers of their difficulty in producing honey, create employment opportunities and finally increase the economic potential of the Nigerian state through exporting of honey and its products.

Keywords: honey, beekeeping, honeycomb, honey extractor, hydroxymethylfurfural (HMF)

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1 Introduction

Beekeeping is an applied science of rearing honey bees for man's economic, health and other benefits (Vural and Karaman, 2009; Shrestha, 2018; Dia et al., 2018). The common African honeybee (*Apis Mellifera Adansonni*), live throughout the year in colonies consisting of a queen or mother bee, which is a fertile egg-laying female, and about 10,000 to 200,000 worker bees called drones that may be present in the colony only during the reproductive season. Honeybees naturally build their honeycomb on trees, inside caves and under the roof of buildings. However, people also keep bee colonies as a form of business venture (Dia et al., 2018). The main reason for keeping bees by farmers is to extract the honey they produce. The honey has been used for

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dressing wounds, as an anti-diarrhea drug, in alcoholic drinks, tobacco curing, bakery and confectionery and in manufacturing of cosmetics. Besides, other honey products like bee wax, propolis, bee venom, and royal jelly are foreign exchange earning commodities for some countries. Honey, the natural food of the honey bee, is described as man's sweetest food (Codex Alimentarius Commission, 2001). Honey is a sweet, thick, supersaturated sugar solution produced by honeybees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, which the bees transform by combining with specific substances of their own, deposit, dehydrate, store, and leave in the honeycomb to ripen and mature, to feed their larvae. Bee honey is composed of fructose, glucose, and water, in varying proportions; it also contains several enzymes and oils. The composition of honey is greatly influenced by both natural and anthropogenic factors which vary based on botanical and geographical origins (Rahman et al., 2019).

Honey is a traditional medicine or food in nearly all societies and whether sold simply at village level or packaged more sophisticatedly, honey generates income and can create livelihoods for several sectors within a society (Chikamai et al., 2009). Beeswax is also a valuable product from beekeeping, although in some places its value is not appreciated. One of the key challenges faced by local farmers or honeybee keepers is the extraction of honey from the honeycomb. It is therefore imperative that machines be designed that will help the local farmers in not only increasing production to meet the demands but also in extracting honey from honeycomb in a more hygienic process. The recent increase in the demand of honey is because of its great

that apart from the known basic hive tools, many of the materials needed for honey extraction are either non-existent or kept by quite a few. The honey extractor was reserved at the centre of the Pyrrolizidine Alkaloids (PAs) for demonstration purpose. All equipment for low technology beekeeping must be made locally as reported by Martin et al. (2011). They noted that beekeeping equipment should not be used unless the infrastructure exists for manufacturing it locally. Most of the

economic importance which ranged from numerous uses as food to medical relevance. To meet this demand requires extracting honey from the honeycomb in an efficient way different from the obsolete and traditional methods currently used by local beekeepers. To remove the honey from the combs efficiently, there is need for a mechanical device for the removal of honey from the honeycombs without compromising the quality or the natural form of the honey (Shaaban et al., 2019). This can be achieved through the design of an extractor.

It has been reported that the microorganisms which affect the quality of honey usually come from the nectar and pollen, but more particularly from the processing method, areas and containers which are usually not hygienic (Adadi and Obeng, 2017). Presently, Nigeria honey is being adulterated and fall short of imports to other countries (Ayansola and Banjo, 2011). This has been attributed to quality issues arising from the traditional method of honey extraction currently used by honeybee keepers, which impacts negatively on the quality of the honey. Shaaban et al. (2019) believed that if beekeeping is being promoted and encouraged, then it must be wholly sustainable, using equipment, which is available locally. He further stated that although equipment can be imported to serve as a prototype, small-scale beekeeping can only be economical in the long-term with equipment, which can be serviced and manufactured locally. Research work of Assefa (2009) and Abera et al. (2016) reported that one of the major problems facing the profitability of beekeeping for honey production in developing countries, particularly in among African countries is the lack of appropriate equipment for honey extraction. Assefa also (Assefa, 2009) in his study reported equipment or honey extractors used in developed or industrialized countries are non-existence in Nigeria as well as in many other African countries (Assefa, 2009). Due to their costs and maintenance requirements is usually well above farm household possibilities. It is therefore expedient that honey extractor is fabricated locally using available local materials and designed and developed for the extraction of honey from honeycombs in developing countries, particularly in Nigeria. The extracted honey will be characterized and compare it to international standards in a bid to validate our results.

The study is aimed at designing and fabricating a machine capable of extracting honey from honeycombs to be used by small and medium scale beekeepers in developing communities. The objectives are to carry out a performance evaluation of the honey extractor and determine and compare some quality-dependent physiochemical properties of the machine and hand squeezing traditionally extracted honey.

2 Materials and methods

2.1 Limitation of the study

This study is limited to the design, fabrication and performance evaluation of a honey extractor excluding the extraction of heather honey which is different from other honeys. Heather honey is thixotropic or jelly-like and must be pressed out of the combs or heated, causing the honey to become temporarily fluid, so that it can be extracted in a conventional extractor. The limitation of this study does not involve the study of the physicochemical properties of honey.

2.2 Research design

This study was carried out in three phases: the first phase was the characterization of honey by local processors in Nsukka, Enugu state and comparison with International Standards. The second phase was the design and fabrication of a model honey extracting machine while the third phase involved the performance evaluation of the designed honey extracting machine followed by the characterization of the physicochemical properties of the honey extracted and compared with international standards. The physicochemical properties of the honey extracted by the local processors and that extracted using the designed machine were compared using statistical analysis.

2.3 Honey samples

Freshly harvested honeycomb is obtained and divided into two portions. The first portion was given to a local honey processor who used the traditional method of honey extraction which involves hand pressing or mashing of the honeycomb against a strainer to extract the honey. The second portion of the freshly harvested honeycomb is used for the performance evaluation of the designed machine. The extracted honey samples were subjected to physicochemical analysis. The honey samples are stored in bottles which is the common container used by beekeepers for honey storage after extraction. All samples are stored at ambient temperature for two days before laboratory analysis

2.4 Material selection for construction

When selecting engineering materials, especially for food processing equipment and in particular honey processors, the overriding consideration for material selection is its ability to resist corrosion. Since honey is an acidic food with a pH of about 3.9, Ojeda et al. (2004) the material used for the construction of the main parts of the machine was stainless steel. This material is corrosion-resistant with sufficient strength and is easy to work on during fabrication. Though a little bit expensive, the material selected (stainless steel) satisfies both processing and mechanical requirements, allowing for maintenance, replacement, as well as offering safety with no product contamination. Materials not certified for food processing was not used where there is no direct contact with the honey to reduce the cost of fabricating the machine.

2.5 Design goals/considerations

Before the design of the honey extracting machine, some goals were set which were seen as sustainable design strategies. These design goals included:

a) To design the machine such that it maintains and protects the cleanliness of the honey.

b) Materials which are food-safe and honey-safe should be used where appropriate.

c) The design should be such that the machine is easy to use, maintain and repair by the users who may have little or no formal education.

d) To increase the overall efficiency of the honey extraction process while maintaining its quality.

e) To use existing pre-made components where possible, and materials and components that are readily available; and

f) To minimize the use of direct human energy as much as possible in honey extraction with a design that is less complex in mechanism, fabrication, and operation of the machine.

2.6 Design description

Honey processing equipment usually consists of centrifugal extractors, presses, processors (warmer/pasteurizers), holding, settling, and filtering tanks and packs. Centrifugal honey extractors are used to collect honey from honey-comb frames by spinning the frames such that a centrifugal force is created and causes the honey to flow out of the comb, away from the centre of rotation. At high speeds, the honey is flung up against a container wall and then flows by gravity into a lower holding tank. In this design work, the principles of extraction by presses were utilized in the design of new equipment, targeting low cost and equipment suitability for small scale beekeepers. The machine was designed to extract and filter the honey at the same time in one unit equipment. The equipment designed and constructed extracts, honey, from honeycombs using a screw press driven by the bevel gear system in an axle box (Figure 1). No heating device was incorporated into the machine to reduce the viscosity of the honey after extraction as is done by some processors. As much as was possible, the exposure of the extracted honey to the atmosphere is minimized to the barest minimum to reduce the possibility of moisture absorption by the honey as honey has been established to have high hygroscopicity (Samborska and Bieńkowska, 2013). The extractor consists of a 2.5 hp electric motor, an axle system, pulleys and belt, hopper/extraction chamber, pressure plate, and threaded screw shaft, the strainer, honey collector and the machine frame (Figure 1).

The hopper/extraction chamber was made of two boxes – one internal and the other external. The internal chamber was made of a perforated 1.5 cm thick stainless plate having dimensions of 35 cm height, 45 cm length and 35 cm breadth. The perforations on the plates are of 5 mm in diameter. The perforations were for the easy flow of the extracted honey into the honey collector from any part of the inner extraction chamber. The choice of 1.5 cm thick plate for the internal chamber was for the plate to be able to withstand the pressure exerted on it during the pressing of the honeycomb against it. The external chamber was made of 1 cm thick stainless plate which covered the sides of the inner chamber with a gap of 10 cm between the internal and the external chamber. The chamber was equipped with a cover which is usually closed after loading the chamber to minimize moisture absorption by the extracted honey. The volume of the internal extraction chamber is 55,125 cm^3, at any extraction batch, only about two-thirds of the volume is utilized amounting to an effective volume of 36,750 cm^3. Inside the inner extraction chamber, is the pressure plate which is made of 2 cm thick plate with perforations of 10 mm diameter for easy flow of the extracted honey from the honeycombs when pressed. The pressure plate was of the dimension 33 cm in height, 33 cm in breadth and 2 cm in thickness.

A threaded screw shaft of 5 cm diameter and 90 cm length is screwed to the centre of the plate which ran through a bevel gear system within the axle such that the clockwise and anti-clockwise rotational motion of the axle resulted in the translational forward and backward motion of the thread screw shaft. The threaded screw is held in place using a 5 cm screw fixed at the entry point of the threaded shaft on one side of the external part of the extraction chamber. The axle was driven by a 2.5 hp electric motor and the clockwise and anti-clockwise rotational motion of the motor was controlled using a switch. The axle and the motor are connected through pulleys and belt connection. Below the hopper/extraction chamber is the honey collector made of 5 mm stainless steel plate slanted at an angle of 50^o to the horizontal for the easy flow of the extracted honey by gravity considering that honey has high viscosity at ambient temperature (Sopade et al., 2003; Bhandari et al., 1999). The flow was concentrated towards a pipe of 2 cm diameter where the honey is collected into bottle containers. The strainer used was a fine cloth mesh, which removes impurities from the honey, which may include pieces of comb, dead bees, crystallized honey particles, and other debris, as it could easily be cleaned and replaced.

All the components of the machine are held in place by the frame of the machine made of angle bars. The frame supporting the extractor was made of 50 × 50 mm angle iron bars wielded together to support and hold the extractor together. Bolts and nuts are used to hold the frame where necessary. The orthographic views of the machine are shown in Figure 1.

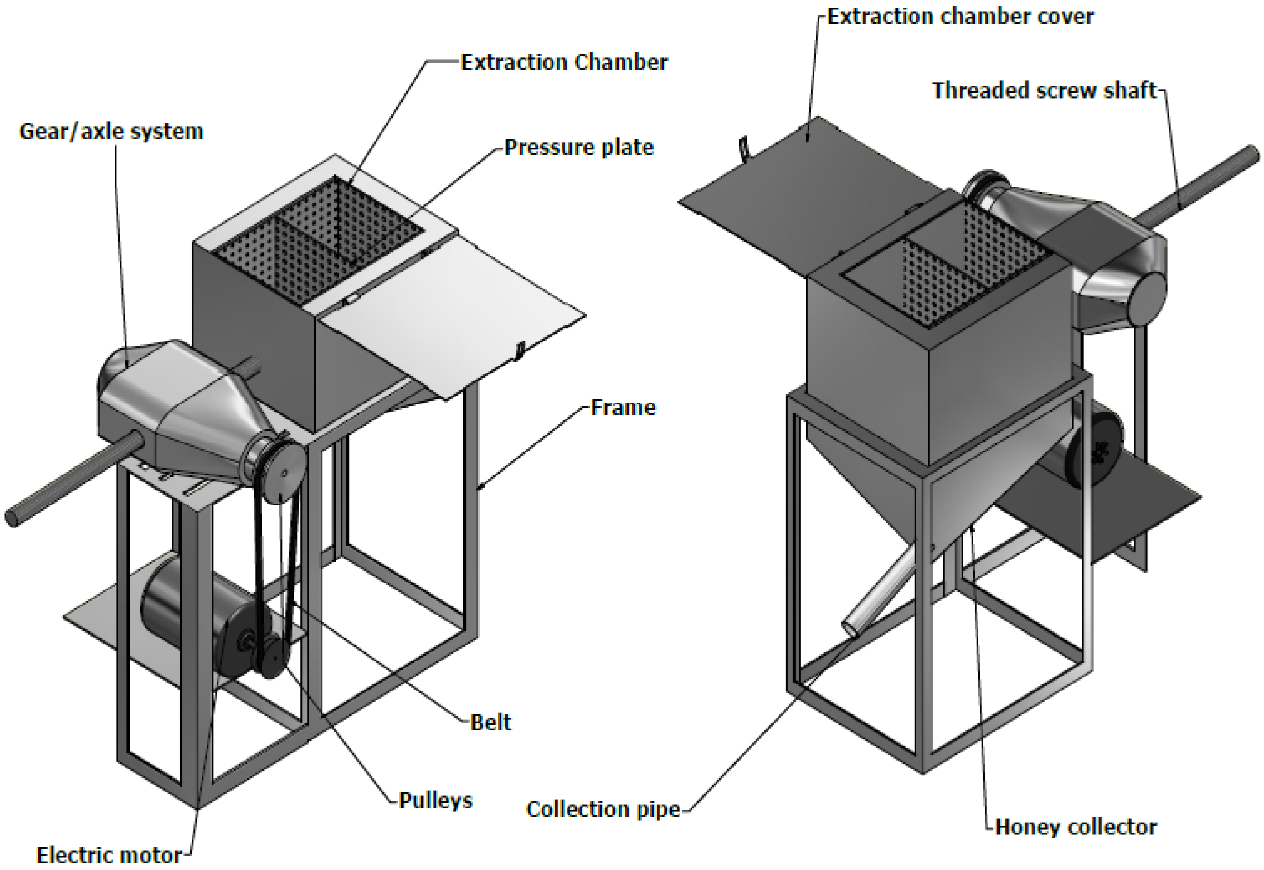

Figure 1 Labeled view of the honey extractor

2.7 Mechanism of honey extractor

The dimensional views of the honey extracting machine designed and constructed is as shown in Figure 2. The honey extractor was designed to extract honey from honeycombs when pressed against a fixed wall. In the operation of the machine, the electric motor is switched to its anti-clockwise motion to drive the pressure plate to an already marked out point to allow for the loading of the hopper/extractor chamber. The fine cloth mesh is laid out in the extractor chamber and then filled with cut honeycombs. The number of honeycombs poured into the chamber laid with the fine cloth mesh depends on the size of the cloth as the combs would be tied up with the cloth before honey extraction. After loading the chamber, the honeycomb is wrapped with the cloth and then the clockwise motion of the electric motor activated to drive the pressure plate through the threaded screw shaft in the forward motion to press the comb against the fixed wall of the inner part of the extraction chamber. At the point where the honeycomb tied in the strainer (fine cloth mesh) is firmly pressed, the machine is turned off and the honey is allowed to drip out of the cloth material while the extracted honey is collected through the collector pipe. The compression of the combs raised the temperature of the honey as they have been extracted which reduced the viscosity of the honey increasing its flow rate. After about 2-3 minutes, the anti-clockwise motion of the electric motor is actuated, and the forward translational motion of the threaded screw shaft is reversed for the wax which remains in the strainer to be removed.

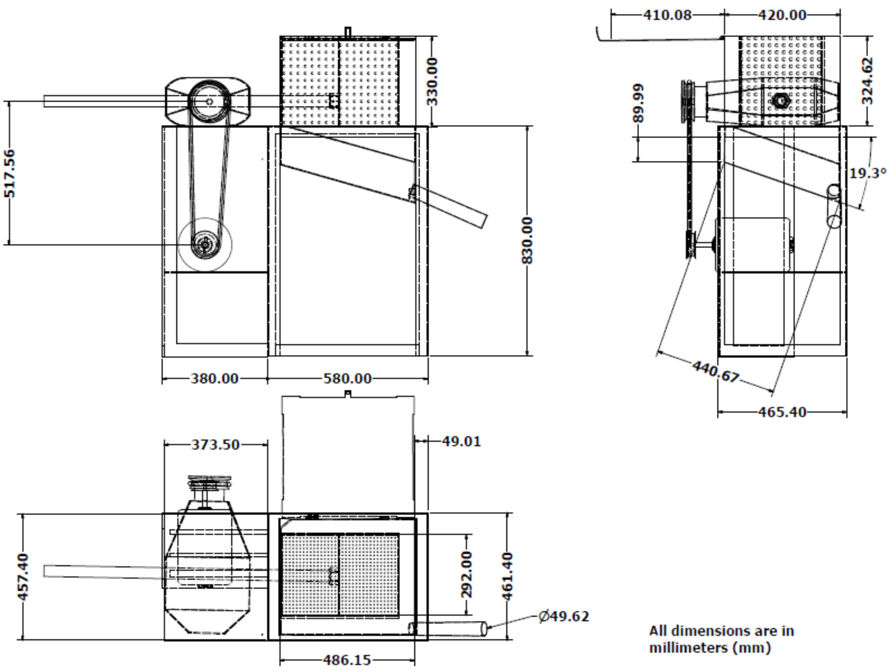

Figure 2 Detailed dimensional views of the honey extractor

3 Results and discussions

3.1 Performance evaluation

The result of the performance evaluation of the designed and fabricated honey extractor in comparison with that of the traditional extraction method is shown in Table 1. The mean extraction rate for the honey extractor machine, defined as the rate at which honey was extracted from the honeycomb with time, was 69.0 kghr^{-1}. This is significantly higher (p<0.05) than the extraction rate calculated for the traditional method which was 6.4 kghr^{-1} of honey. A similar result was reported by Maradun and Sanusi (2013), who designed a hand-driven screw press for honey extraction. Mean extraction rate of 2.71 kghr^{-1} of honey was reported for the traditional method using the weight and press method while mean extraction rate of 32.58 kghr^{-1} of honey was reported for the designed hand-driven honey extractor press. The extraction/machine efficiency which indicates equipment performance was 86.3 % for the designed honey extractor and 59.1 % for the traditional method which is squeezing and mashing of the honeycomb to extract the honey. The mean extraction efficiency of the honey extractor was significantly higher (p<0.05) than that reported for the traditional method. In the work of, (Maradun and Sanusi, 2013) also reported an extraction efficiency of 56.3 % for the traditional method and 70.6% for hand-driven screw press for honey extraction while Akinnuli et al. (2013) reported an extraction efficiency of 82.0 %. The results of the extraction rate and extraction efficiency show a clear improvement of the designed honey extractor over that of the traditional method. Furthermore, bubbles were not observed in the honey collected from the honey extractor unlike the honey from the traditional extraction method. The bubbles have been attributed to air being trapped in the honey and reduce significantly the market value of honey (Maradun and Sanusi, 2013).

Table 1 Result of the performance evaluation of honey extraction methods

Experimental Run	Extraction Rate (kg hr^{-1})		Extraction Efficiency (%)	
	Honey Extractor	Trad. Method	Honey Extractor	Trad. Method
1	68.9	6.29	86.12	59.00
2	69.0	7.06	86.25	59.13
3	69.1	5.85	86.38	59.25
Total	207.0	19.20	258.75	177.38
Mean	69.0*	6.40	86.25*	59.13
Stand. Dev.	0.1	0.61	0.13	0.13

Note: *Mean value of the honey extractor is significantly different from the mean value of the traditional method at 5 % (p<0.05).

3.2 Physico-chemical analysis

The result of the physicochemical analysis carried out on the honey extracted using the honey extracting machine and the traditional method is shown in Table 2 along with the international standard of Codex Alimentarius Commission, (Codex Alimentarius Commission, 2001). In all the physicochemical properties investigated, both the honey extracted using the designed honey extractor and that of the traditional method was within the international standard limits except for the ash content and the electrical conductivity which are higher. The ash content of honey is affected by certain nitrogen compounds, minerals, vitamins and aromatic substances (Mairaj et al., 2008). Perez-Aguilue et al. (1995) noted that the ash content of honey is also affected by the botanical origin and the harvesting technique used. The honey from the honey extractor had an ash content of 0.76% while that of the traditional method had an ash content of 0.84 %. Fatimah et al. (2013) carried out an analysis of the biochemical composition of honey samples from North-East Nigeria and reported on ash content varying from 0.28 to 0.60 g 100 g^{-1} with an average of 0.47 g 100 g^{-1}. El-Sohaimy et al. (2015) reported ash content of honey to be within the range of 0.23±0.02 % to 2.33±0.02 %. The electrical conductivity reported for honey samples from the two extraction methods were higher than the standard limits. This could be attributed to the high ash content which influences the electrical conductivity of honey (Codex Alimentarius Commission, 2001). Electrical conductivity is a good criterion of the botanical origin of the honey and today it is determined in routine honey control instead of the ash content. This measurement depends on the ash and acid content of honey; the higher their content, the higher the resulting conductivity as there is a linear relationship between ash content and electrical conductivity (Oddo et al., 1995; Kropf et al., 2008). It was also observed that in all the properties investigated, the honey extracted using the machine presented more desirable values than that of the traditional extraction method.

Table 2 Physico-chemical properties of honey from two extraction methods

Properties	Honey Extractor	Traditional Method	International Standard*
Moisture content,%	18.75	22.66	Not more than 20%
Electrical conductivity, mS cm^{-1}	1.466	1.602	Not more than 0.8 $mScm^{-1}$
Ash content,%	0.762	0.840	Not more than 0.6%
Free acidity, $meqkg^{-1}$	38.77	40.24	Not more than 50 $meqkg^{-1}$
Insoluble matter, g 100 g^{-1}	0.0378	0.56	Not more than 0.5 g 100 g^{-1}
HMF, $mgkg^{-1}$	42.9	44.0	not more than 80 $mgkg^{-1}$
Glucose, g 100 g^{-1}	39.629	37.853	Sum of both not less than 60 g 100 g^{-1}
Fructose, g 100 g^{-1}	36.830	37.642	
Sucrose, g 100 g^{-1}	1.339	1.358	Not more than 5 g 100 g^{-1}
Diastase	40.0	44.0	Greater or equal to 8

Note: *(Codex Alimenatarius Commission, 2001)

The moisture content of honey is related to its degree of fermentation due to exposure to the environment. It is important to note that the moisture content of honey is affected by the harvest season and the degree of maturity reached in the hive and it is an important parameter of the shelf-life of honey during storage (Pérez-Arquillué et al., 1995). The control of moisture content is an important quality requirement of Codex Alimentarius Commission Standards (Codex Alimentarius Commission, 2001) which set a maximum limit of 21 %. The moisture content of the honey using the two extraction methods are below the maximum limit with the traditional method having a higher value of 22.66 %. This could be attributed to the long-time exposure to the atmosphere during the extraction process. It is important to also note that honey is a high hygroscopic substance. Mairaj et al. (2008) reported that the moisture content of Pakistani honey ranged from 14.5 %-18.23 %, while Fasasi (2012) reported the mean moisture content of some samples of Nigeria honey to be 17.9 %. High free acidity in honey samples, as was stated by Mairaj et al. (2008) suggests that the honey had fermented sometimes, and the resulting alcohol changed to acetic acid by bacterial action. The maximum limit stated in the Codex standards is not more than 50 meqkg^{-1}. The value determined for the honey from the two extraction methods were within the standard limits with the honey extracted from using the machine having the lower value (Table 2). The free acidity of honey samples had been reported to range within 19.5-38.0 meq kg^{-1}, (Mairaj et al., 2008). The measurement of the insoluble matter is an important means to detect honey impurities that are higher than the permitted maxima, (Codex Alimentarius Commission, 2001). Insoluble matter content of 0.0378 g 100 g^{-1} is reported for the honey extracted using the designed machine while a value of 0.56 g 100 g^{-1} is reported for honey extracted using the traditional method which is higher than the maximum value of 0.5 g 100 g^{-1}, (Codex Alimentarius Commission, 2001). The high insoluble matter could be attributed to exposure to the environment and due to impurities from the containers used during the extraction process.The hydroxymethylfurfural (HMF) which is affected by temperature rise during honey extraction is inversely proportional to the quality of honey and is dependent on pH, moisture content, heat process and storage temperature (Fallico et al., 2004; Mairaj et al., 2008; El-Sohaimy et al., 2015). The presence of high level of HMF above 80 mg kg^{-1} (standard) suggests the possibility that the honey has been adulterated with invert syrup, (Swallow and Low, 1994). The HMF of the honey extracted using the traditional method (44.0 mgkg^{-1}) was with the international standard limit, it was higher than the value recorded for the honey sample extracted using the honey extractor (Table 2). The sugar content of the honey samples that is the glucose, fructose, and sucrose, for the honey from the extractor and the traditional method of honey extraction is within the standard limit. For the honey obtained from the honey extractor, they are observed to be 39.629, 36.830 and 1.339 g 100 g^{-1} for the glucose, fructose, and sucrose, respectively while for the honey extracted using the traditional method, they are observed to be 37.853, 37.642 and 1.358 g 100 g^{-1} for the glucose, fructose, and sucrose, respectively. Fatimah et al. (2013) and Oddo et al. (2008) stated that even though honey contains an active sucrose splitting enzyme (sucrase, glucosidase), the sucrose level in honey never reaches zero. The results of the sugar analysis of 18 honey samples obtained from northeast Nigeria showed that the fructose contents varied between 37.68 and 40.31 g 100 g^{-1}, the glucose contents varied from 27.25 to 39.56 g 100 g^{-1} while the sucrose varied from 0.53 to 3.29 g 100 g^{-1}. Fructose and glucose are the dominant sugar types in honey, which although no limits have been fixed for their values, their sum (Fructose + glucose) has been fixed at a value of ≥ 60 g 100 g^{-1}, (Codex Alimentarius Commission, 2001). Generally, the sugar spectrum of honey depends upon the sugars present in the nectar and the enzymes present in the bee and nectar (El-Sohaimy et al. 2015).

Honey diastase activity is a quality factor, influenced by honey storage and heating and thus an indicator of honey freshness and overheating (Schade et al., 1958; Khan et al., 2015). Although there is a large natural variation of diastase, the present standard is a minimum diastase number (DN) value of 8. The value obtained for the samples which are 40 and 44 for the machine and traditional method extracted honey samples are higher than the minimum value. The lower value reported for the machine extracted honey could be attributed to the heat generated during the pressing of the comb. When interpreting diastase results, one should note that certain unifloral honey has a naturally low diastatic activity while diastase activity is expected to diminish upon storage (Özcan and Ölmez, 2014; Assia and Ali, 2015). In all, honey samples vary in quality, (Rahman et al., 2019) on account of numerous factors like the origin of honey, bee activity, bee food, the period of harvest, condition of storage, the freshness of honey and technique of extraction.

4 Conclusions

The performance evaluation of the machine was carried out and compared with that of the traditional method of honey extraction. Mean extraction rate and efficiency of 69 kg hr^{-1} and 86.3% are reported for the machine while extraction rate and efficiency of 6.40 kg

hr^{-1} and 59.1% are reported for the traditional method. These mean values are significantly different from each other at 5% significant level. The physicochemical analysis carried out showed that the properties of the honey extracted using the designed machine presented more desirable results compared to the honey extracted using the traditional method and are within the recommended limits stipulated in international export standard except for the ash content and the electrical conductivity. Perspective on the effect of temperature on the quality of honey extracted by the designed machine must be modeled as it is not covered by this research.

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Appendices

Table A1 Detailed result of the performance of the traditional method

S/N	Wt. of honeycomb (Kg)	Wt. of extracted honey (kg)	Wt. of beewax (kg)	Time taken to extract honey (hr)
1	8	4.72	3.23	0.75
2	8	4.73	3.24	0.67
3	8	4.74	3.24	0.81
Total	24	14.19	9.71	2.23
Mean	8	4.73	3.236666667	0.743333333
Std. Dev	0	0.01	0.005773503	0.070237692

Table A2 Detailed result of the performance of the honey extractor

S/N	Wt. of honeycomb (Kg)	Wt. of extracted honey (kg)	Wt. of beewax (kg)	Time taken to extract honey (hr)
1	8	6.89	1	0.1
2	8	6.9	1.01	0.1
3	8	6.91	1.02	0.1
Total	24	20.7	3.03	0.3
Mean	8	6.9	1.01	0.1
Std.Dev	0	0.01	0.01	1.69967E-17