Design and Fabrication of a Low-Cost Centrifugal Honey Extractor

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ABSTRACT

The traditional and screw press techniques were adopted and utilized extensively by Nigerian honey producers and these have led to the absence of a good quality and timely produced honey devoid of foreign materials and marketable by international standard. Ample information from literature survey showed that the Langstroth hive which is beyond the reach of common Nigerian bee farmer due to its high cost. A 750 W indigenous centrifugal honey extractor was developed using locally sourced materials. The machine was tested at extraction speed levels of 272, 287, 351, 1445, 1730, 2300 and 2575 rpm. Quantifiable extractions were obtained at all speed levels except at a speed of 2575 rpm where a vicious crushed extract of honey and comb was observed. High speed extraction was not favorable as it resulted in the destruction of the honey comb. Honey extracted at the two lower speeds of 272 and 287 rpm were found to be purer with less foreign materials and of high quality. This indigenous centrifugal honey extractor is also favorable for extraction of honey from other types of hives apart from the Langstroth hive and is marketable.

Keywords: *Centrifugal, Honey-Extractor, Extracts, Speed*

INTRODUCTION

Many reports on honey production (NHB, 2010; Root and Root, 2005; Hilmi *et. al.,* 2011; Geckler, 2009; Verwijs, 2011; Standifer *et. al,.* 2015; Vidal and Isrealoff, 2000; Kántor, 1999; Rainer, 1996 and Eva,1983) showed the great potentials, importance and the usefulness of honey product to our day to day life. Honey products are of immense benefit to our diet since they supply the much-needed body sugar in the simplest form that requires no further digestion by human digestive system. This sugar from honey is unlike the refined sugar being widely sold in the market and consumed generally by larger percentage of the world populace. Refined sugar must be broken down from complex to simple sugar before it is digested in human system. Over years of consumption of refined sugar poses serious health issues in the life of consumers which is absent in those who take honey products. Consumption of honey gives good health due to the medicinal values it adds to the consumers' diet. Claims of curative effect and maintenance of good health derived from consumption of honey products were mentioned by Edgar (2011).

Extractors developed by previous researchers were reported in Geckler and Rudd (2003) and Herbert (1975). Among the producers of honey in the world, the production techniques predominantly used by Nigerian producers is obsolete and at low scale level. This is grossly unacceptable economically considering the great economic potentials obtainable from honey production in Nigeria. Maximum utilization of these potentials would bring great benefits to Nigerians in terms of good health for consumers and as well as generate immense income and foreign earnings for the nation. This would improve the Gross Domestic Product of Nigerian economy. Honey business was estimated to generate between $ 45,000 and $52,000 annually (Gaby *et. al.,*2007*).*

The advanced technique of extracting honey, centrifugal honey extractor, used in developed countries for honey production is yet to be adopted in Nigeria. This situation might be attributed difficulty in accessing the Langstroth hive being experienced in Nigeria. Honey harvested from this hive can easily be extracted using the centrifugal extractor. The advantage of this hive was that it safeguards the comb from being destroyed (NHB, 2010). This is not attainable in other types of hives adopted and predominantly used by Nigerian producers.

These local producers using other types of hives would require a development of an indigenous centrifugal extractor that would enable them to extract honey from the comb without destroying it, since the screw press method used extensively by most producers in Nigeria destroys the honey comb. This local method is characterized by the crushing of honey extracts and the honey comb. Another disadvantage is that the screw press is operated manually. Extracts from this method still require further purification which increases the overall energy input for the process. The method is also associated with loss of time of production which is due to the fact that the crushed honey comb must be reconstructed by the bees every time honey is harvested from the hives. This time for reconstructing the new comb each time honey is harvested is a waste of production time and resources. This problem could be eliminated with the development and adoption of an indigenous centrifugal honey extractor for local producers. The new method offers the return of an intact structured comb to the hive for timely reproduction of fresh honey into it by the bees. This action would reduce time of production and resources for all the stakeholders; led to the production of high quality and pure honey extract which in turn fetches high market values. Pure honey extracts attracts high values of $ 0.92 – 1.05 per pounds in the world market today as reported in Gaby *et. al*. (2007). Gaby *et. al.* (2007) stated that the quality of the honey extracted determined the prize in the market. The authors also presented a new design of a vertical centrifugal extractor, costing $196.98, and was claimed to be an improvement on the existing one. For this design an indigenous horizontal extractor was conceived and developed.

MATERIALS AND METHOD

Theoretical Background and Design Concept and Calculation

There is need to estimate the force required to extract honey from the comb as the shaft spins the comb in the centrifuge. Root (2005) reported that honey at 25^{o} C (77^{o} F) have a viscosity of 400 poise.

This value was used in this work since the prevalent room temperature is 25^{0}C

$$400 \text{ poise} = 40 \text{ PL} \quad (1)$$

where PL is 1 Poiseville is equivalent of η = 40 Kg/ m.s (Vicosity)

For extraction of honey to take place in the extractor, the centrifugal force must be more than F_c which is the force required to cause the flow of honey from a given honey cell

But F_c is related to η by equation:

$$\eta = \frac{F \times L}{A \times V} \quad (2)$$

Inputting the value of η in Equation 1 gives:

$$40 \text{ kg/m.s} = \frac{Fc \times L}{A \times V} \quad (3)$$

Solving for F

$$F_c = [\frac{40 \times A \times V}{L}] N \quad (4)$$

Where V is the velocity of spinning the comb L is thickness of the honey comb as shown in Figure 1

A is the cross-section area of the honey comb orthogonal to the direction of spinning and A is calculated by multiplying B and W as shown in Figure 1

The velocity V for machine operation is determined by assuming a suitable revolution speed for centrifugal extractor,

From literature survey a low-speed extractor is desirable to prevent aeration of honey. An angular revolution speed (N) of 300rpm was selected

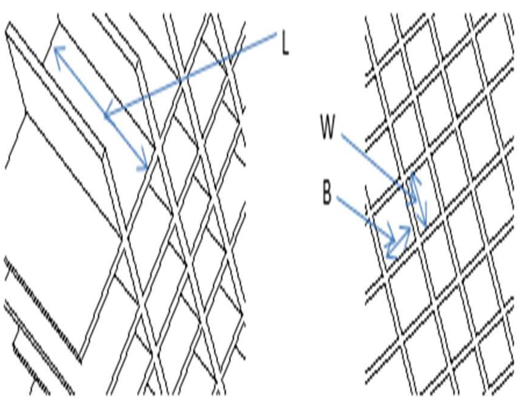

Fig: 1 Sectional views of the Honey Comb: W, width, B, breath and L length of comb respectively.

But

$$V = \frac{\pi r N}{30} \text{ m/s} \quad (5)$$

r = 85 mm = 0.085 m

$$V = \frac{\pi \times 0.085 \times 300}{30} \text{ m/s}$$

V = 2.67 m/s

$$A = B \times W \quad (6)$$

B = 10 mm or 0.01 m

W= 25 mm or 0.025 m

$A = 0.01 \text{ m} \times 0.025 = 2.5 \times 10^{-4} m^2$

L = 30 mm or 0.03 m

Substituting all the above values in Equation 3

$$\mathbf{F_c} = [\frac{40 \times 2.5 \times 10^{-4} \times 2.67}{0.03m}] \text{ N} = 0.89 \text{ N}$$

Estimated dimensions of a standard honey comb from the hive according to Gaby *et al.* (2007) is given by

Estimated area A_E = 0.475 m × 0.232 m

= 0.1102 m^2

$$R_A = \frac{\text{Estimated area of honey comb}}{\text{Estimated area of a call of honey}} = \frac{0.1102\ m}{2.5 \times 10^{-4} m}$$

= 440.8

The total force (F_t) required to extract honey from a whole honey comb is given as

$F_t = F_c \times R_A$ = 0.89 × 440.8 = 392.312 N

The estimated power requirement can be calculated by the expression

$$P = F \times V \quad (7)$$

But V = 2.67 m/s

P = 392.312 N × 2.67 m/s = 1047.47W =1.05 KW

Machine testing and operation

Sample of honey comb was obtained from a Kenya top bar hive at the industrial park processing unit of the Federal University of Agriculture Abeokuta (FUNAAB). The preconceived isometric view of the extractor is shown in Fig. 2. It was design and fabricated in the Agricultural Engineering Department workshop of FUNAAB. The machine parts were made from locally sourced materials, the components parts, function and specification are given in Table 1 while the orthographic projections of the design are shown Fig 3.

Table 1: Components parts of centrifugal extractor

RESULTS

A preliminary testing of the machine to observe the extraction performance between high speed of 1730 and 2575 rpm gave an extraction result shown in Table 2 At the highest speed of 2575 rpm no extraction was obtained but rather a crushed mixture of the comb and honey was obtained. Further test conducted in the range lower than this speed gave the result shown in Table 3. The quantity and quality of honey extracted is also shown in Plate 1.

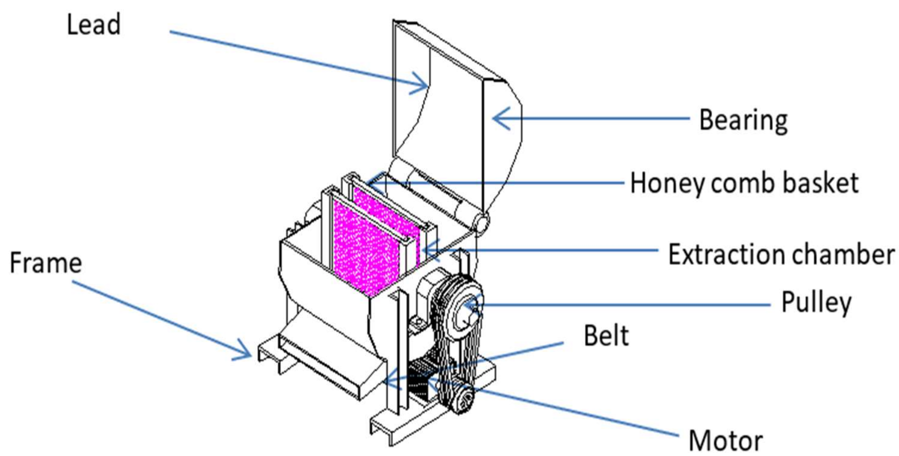

Fig. 2: Conceptual Isometric view of the centrifugal Honey Extractor

Table 1: Components parts of centrifugal extractor

S/N	NAME	SPECIFICATION	FUNCTION
1.	STAINLESS STEEL SHEET	GAUGE 19	FOR FORMING THE BARREL FOR HONEY EXTRACTION
2.	ANGLE IRON	35CM X 35CM X 0.6CM	MACHINE SUPPORT
3.	WIRE MESH	40CM X 20CM X 3.5CM	HONEY COMB ENCLOSURE
4.	SHAFT	62.5CM, DIAMETER 2CM	SECURE WIRE MESH
5.	PILLOW BEARINGS	2 CM INTERNAL DIAMETER	SHAFT SUPORT
6.	PULLEYS	75 CM DIAMETER 167 CM DIAMETER	SHAFT AND MOTOR DRIVES
7.	BELT	A TYPE	LINKING MOTOR SHAFT PULLEYS
8.	**ELECTRIC MOTOR**	**746-WATT MAXIMUM SPEED 2850RPM**	POWER UNIT
9.	MAIN BARREL	DIAMETER 35cm AND LENGTH 49cm	HONEY COLLECTOR
10.	TRAY	STAINLESS STEEL GAUGE 20	HONEY COLLECTOR

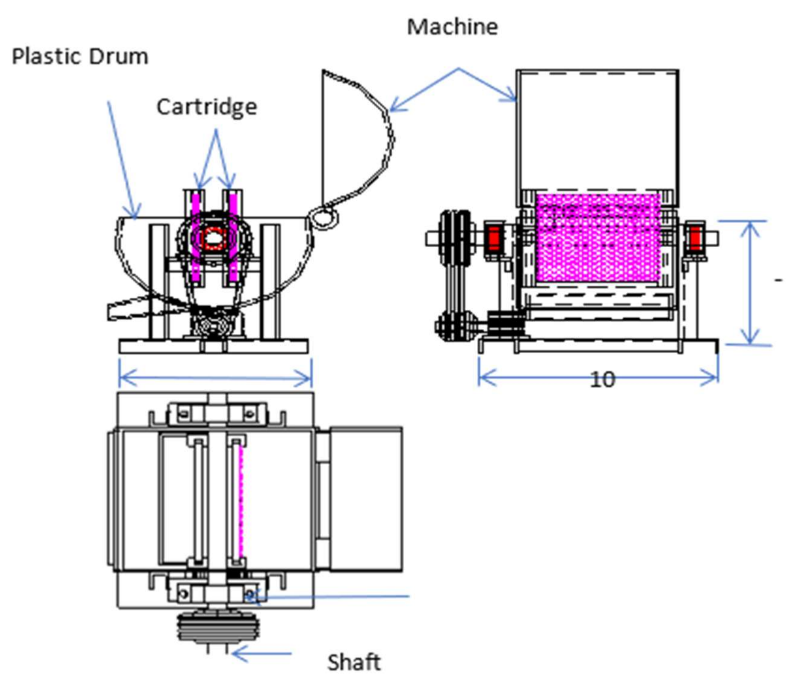

Fig. 3: Orthographic projection of the centrifugal honey extractor

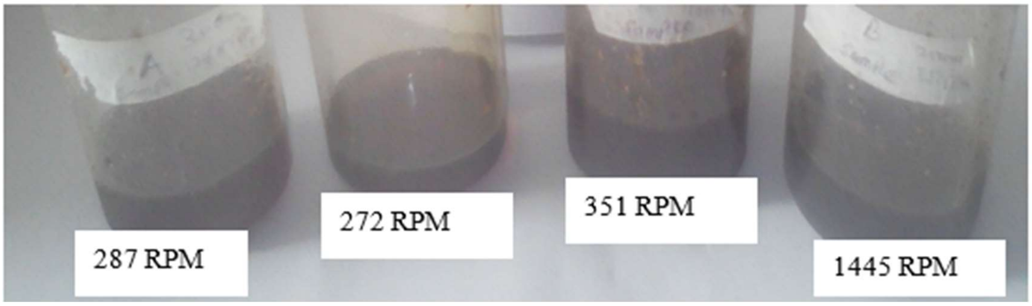

Plate 1 Extracted honey in plastic bottles

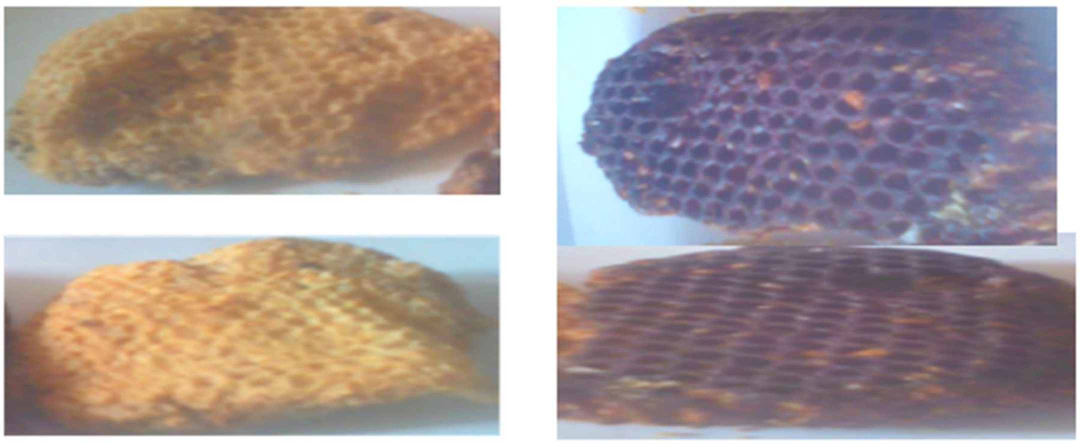

Plate 2 Residue of the wax comb after extraction

Table 2: Result of the preliminary extraction during initial testing of machine developed

MASS(g)	SPEED (RPM)	TIME (S)	OBSERVATION
50	1730	420	EXTRACTION
50	2300	420	EXTRACTION
50	2575	420	NO EXTRACTION
100	1730	420	EXTRACTION
100	2300	420	EXTRACTION
100	2575	420	NO EXTRACTION

Table 3: Further result on the extraction with a modified extraction basket

MASS(g)	SPEED (RPM)	VOLUME EXTRACTED (cm^3)	OBSERVATION/QUALITY
50	1445	137.64	DARKER WITH MORE WAX PARTICLES
50	`351	110.12	DARK WITH LESS WAX PARTICLES
50	287	96.35	LESS DARK WITH FEW WAX PARTICLES
100	272	65.38	LIGHTER WITH MINUTE PARTICLES

DISCUSSION

The result obtained while testing showed that the machine was able to extract honey from the comb. Extraction of honey at high-speed of 2575 rpm was not acceptable, rather than extracting the honey, the machine crushed the honey comb and the honey together thereby making a vicious mixture of the two. Extraction at speed levels of 1730 and 2300 rpm for both 50 and 100 grams of honey gave favorable results though the quantity extracted was so small in terms of weight extracted. For these levels of speed, no mixture with the comb occurred. Further tests conducted on the machine at lower range of speeds gave various volume of extract shown in Table 2. The result showed that as the speed of extraction reduces the volume extracted also reduces. Also in terms of visual quality, the honey extracted at the lower the speed is lighter in colour and has lesser foreign wax particles. The residue of the comb for the highest speed appears dryer than those obtained at lower speeds. This has to do with the volume of honey extracted at this speed. It is more than the other three

The extractor developed was found suitable in extracting honey at speed range of 372 to 2300 rpm. Above a speed of 2300 rpm no extraction was observed. Subsequent modification of the machine design to eliminate the vibration observed at highest speed of 2575 rpm could be resolved however cited literatures favor low speed extraction of honey to prevent over aeration of honey product that can lead to spoilage. Presently the machine is suited to operate in the range of speed of 372 to 2300 rpm. Extraction observed at the low range of speed gave a better quality but at low rate of extraction. Operating the machine at speed ranging from 372 to 1445 rpm gave a favourable yield of honey. The highest yield of extract was obtained at a speed of 1445 rpm. This result showed that as speed increases the centrifugal force causing extraction to take place in the machine also increases thereby leading to high yield of honey at high speed.

CONCLUSION

The extractor was found suitable in extracting honey at low speed of 272 to 341rpm

For this machine only one basket for holding the honey was made, further modification of this component would increase the yield and performance of the machine. Stakeholders in the apiary industries would find this new indigenous machine handy.

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