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# Development of Solar Based Apple Fruit Juice Extractor

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**Abstract:- The research focuses on the development and testing of a solar-based apple fruit juice extractor. Solar panels provide power to the machine, which has overall dimensions of 393 mm X 220 mm X 581 mm and comprises two main compartments: the screw press compartment and the juice extracting compartment. Other components include feeding hoppers, juice sieve, juice collector, waste outlet, transmission belt, and main frame. In operation, apple fruit is introduced into the machine through the first hopper, sliced, and passed into the extracting compartment via the second hopper. The screw press crushes and squeezes the fruit slices to extract the juice, which is filtered through the sieve into the juice collector, while the residual waste is discharged through the waste outlet. At an optimum machine speed of 2400 rpm and a 6 cm blade length, the developed apple fruit juice extractor achieved a juice recovery of 73.60% with a juice extraction efficiency of 92.08%. This machine attained a capacity of 1.326 liters per hour with an 80-watt solar panel.**

***Keywords**:- Apple Fruit, Juice Extractor, Solar Panel, Juice Extraction Efficiency.*

## I. INTRODUCTION

Human health awareness is paramount due to the body's daily needs for optimal functioning. Fruits play a crucial role in human diets, offering abundant vitamins A, B, and C, as well as essential minerals like calcium and iron, promoting overall well-being. However, their seasonal availability poses challenges as they are difficult to store in their natural state, leading to scarcity and high costs during off-seasons. The perishability of fresh fruits exacerbates this issue. Consequently, ongoing research into fruit preservation methods is essential. Juice extraction has emerged as a promising preservation technique, offering a solution to this challenge. Local fruit availability, coupled with the need for cost-effective preservation methods, necessitates the development of extractors using locally sourced materials. This enables the efficient extraction of juice from various fruits, promoting fruit juice consumption for a healthy lifestyle. Mechanical extraction methods, which involve crushing, squeezing, and pressing fruits to obtain juice and reduce bulkiness, offer advantages over traditional hand extraction methods. Mechanization not only saves time but also enhances efficiency, capacity, and reduces spoilage and waste, contributing to improved hygiene and productivity.

Solar energy has been steadily gaining popularity as a technology. Its primary advantage over conventional power generators lies in its ability to directly convert sunlight into solar energy using even the smallest photovoltaic (PV) solar cells. Advancements in solar panels, coatings, and solar tracking have significantly improved the efficiency of solar energy. With ongoing improvements, solar energy is poised to become increasingly economical in the coming years, offering better technology in terms of both cost and applications. Meanwhile, apples, a fruit rich in vitamins C and fiber, play a significant role in supporting the human body's changing needs. Regular consumption of apples can help reduce cholesterol levels in the blood. In contemporary commercial settings, there's a growing demand for apple fruit processors that prioritize improving existing conventional processing methods and equipment. These processors should be easily affordable, environmentally friendly, and energy-efficient to maximize apple juice yield while maintaining quality. With this in mind, the present study aims to develop a solar-based apple fruit juice extractor and assess its performance.

## II. MATERIALS AND METHODS

For the experimentation, 15 kg of Royal Gala variety apple fruits were purchased from the local market. The solar-based apple juice extractor comprises various parts, including a stainless steel kettle with a capacity of 5 liters, juice outlet pipes with a diameter of 25 mm, two DC motors (0.3 HP with a speed of 2700 rpm and 0.1 HP with a speed of 200 rpm), stainless steel blades sized 4.5 cm and 6 cm, a screw press made of chromium material, a belt pulley with a diameter of 30 mm, a battery with a capacity of 75 Ah, and two solar panels each with 40 watts, as illustrated in Figure 1.

### A. Development of Solar Based Apple Juice Extractor

The selection of materials for the development of the juice extractor was based on several considerations. These included the engineering properties of the apple fruits (such as size, moisture content, and crushing strength), chemical properties (including resistance to oxidation and corrosion in all forms), physical properties (size and shape), and mechanical properties (strength, toughness, stiffness, fatigue, hardness, and wear resistance) of the construction materials. Additionally, factors such as material availability, cost, durability, hygiene, and the total cost of the machine were taken into account. Stainless steel was chosen for constructing the screw, cylinder, and juice outlet due to its

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beneficial properties. Stainless steel enhances the durability of the machine because of its resistance to corrosion, ensuring longevity and reliability in operation.

The solar-based apple juice extractor is comprised of several key components, including the feeding hopper, screw conveyor (auger) housed within a cylindrical barrel, waste outlet, juice outlet, and main frame. Designed to operate on the principle of pressing and squeezing, the extractor consists of four main units: the main frame, feed hopper, juice extraction unit, and collecting unit.

The main frame, which forms a rectangular shape, serves as the foundational support for the machine's components, contributing to its compact design and sturdy construction. Mounted atop the juice extraction cylinder, the feed hopper facilitates the mass flow of feed into the extraction chambers. This hopper, characterized by a circular shape and vertical inclination, features circular upper and base openings and is constructed from mild steel sheeting. Within the cylindrical barrel, the screw conveyor and housing play a crucial role in applying shear and compressive forces necessary for crushing the fruit and extracting the juice efficiently.

During operation, the screw within the cylinder maintained a clearance of 2 mm between its diameter and the inside diameter of the cylinder. Fruits were introduced into the machine via the feeding hopper, where they underwent crushing on their path into the cylinder. Within the cylinder, the machine conveyed, crushed, ground, and pressed the fruit with the assistance of the screw conveyor until juice was extracted. This extracted juice was drained through perforations located at the bottom of the cylinder. Any residual material was discharged through the outlet located at the end of the cylinder.

*B. Solar Panel Technology*

A solar panel comprises a collection of electrically connected photovoltaic cells, typically composed of semiconductor materials like silicon, which is the most common material used. When sunlight strikes these cells, its energy is absorbed by the semiconductor material. This absorption of energy causes electrons to be released, creating a flow of electricity in a specific direction due to the electric field generated within the cells. Metal contacts positioned on the top and bottom of the panels draw off this current. The amount of current produced by a PV panel is directly related to the intensity of light it absorbs.

One advantage of employing a higher voltage output from solar panels is the ability to use smaller wire sizes to transfer electric power from the solar panel array to the charge controller and batteries. In the experiment, two 12-volt, 40-watt solar panels were initially utilized.

Solar panel 1: I1 = 40W/12V =3.33A
Solar panel 2: $I2$ = 40W/12V=3.33 A
Total current for solar panels in parallel:
$I = I1 + I2 = 3.33 + 3.33 = 6.66A$

*C. Working of Solar Based Apple Juice Extractor*

Fresh apple fruits were placed on top of the feeding hopper. Using cover plates, the apples were pressed down until they were sliced and fell into the mixing chamber. In the mixing chamber, the slices were converted into pulp by rotating blades fixed at the bottom. Once the apple fruit was converted into pulp, the cock at the bottom of the mixing chamber was opened, transferring the pulp to the screw press section. In the screw press section, the pulp was pressed by the clockwise rotation of the screw, causing juice to exit through the juice outlet section and waste to exit through the waste outlet section.

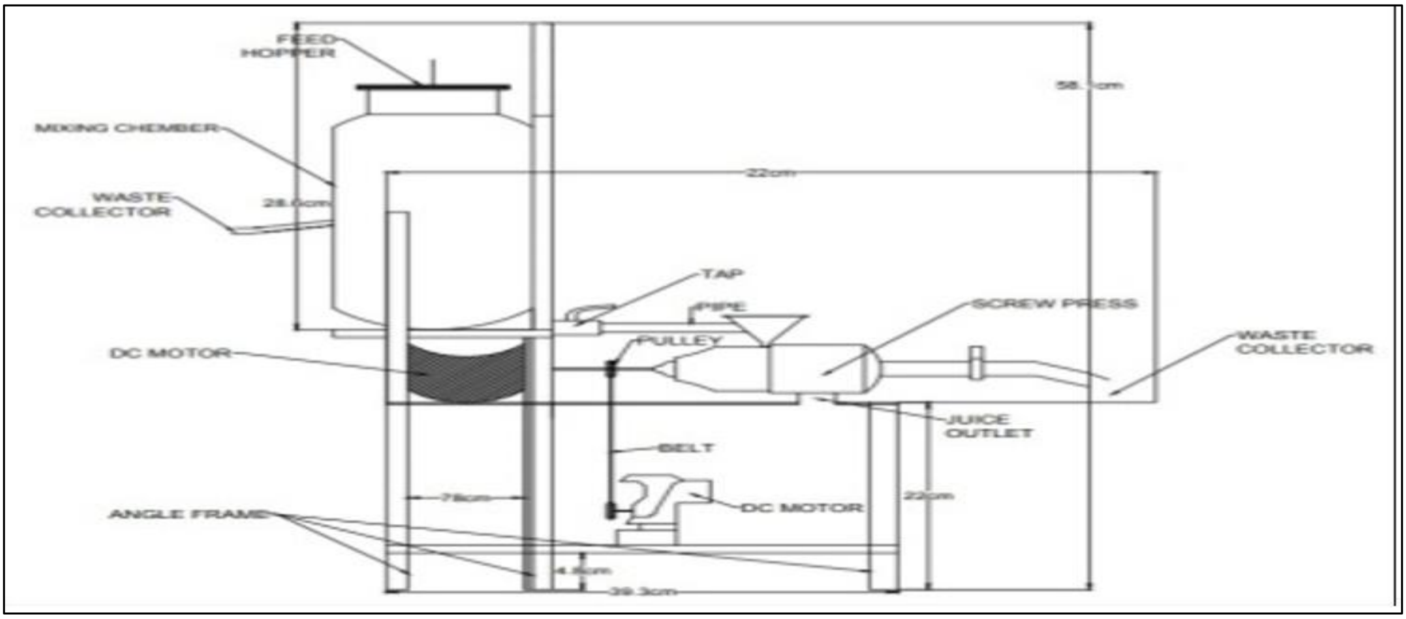

Fig 1: Solar Based Apple Juice Extractor

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Fig 2: Working of Solar Based Apple Juice Extractor

Initially, the fruits were washed properly. One kilogram of the washed fruit was introduced into the hopper of the machine. The handle, which transmits power to the screw shaft, was then operated. The screw shaft conveyed, crushed, and pressed the fruit, extracting juice. The extracted juice and the residue were collected and weighed. Additionally, the time taken for the extraction was noted. The machine was evaluated based on the percentage of juice recovery, the percentage of extraction efficiency, and machine capacity, as shown below.

- *Juice Recovery (%)*

The juice recovery was calculated as the ratio between the total amount of extracted juice collected from the juice outlet to the total amount of input crop as shown by equation (1).

$$Ro= W_f / W_i \times 100 \quad (1)$$

Where,
$R_o$ = juice recovery, %
$W_f$ = weight of extracted juice collected from juice outlet, kg
$W_i$ = weight of input crop, kg

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- *Extraction Efficiency (%)*

This was calculated as the ratio between the total amount of juice extracted by the machine to the total amount of potential juice content of the crop as shown by equation (2).

$$E_{eff} = W_{Tj} / P_{jc} \times 100 \quad (2)$$

Where,
Eeff = extraction efficiency, %
$W_{Tj}$ = total weight of the extracted juice, kg
= $W_f + W_L$
$W_f$ = weight of the extracted juice, kg
$W_L$ = weight of the juice collected other than from juice outlet, kg
$P_{jc}$ = potential juice content of crop, kg
= $MC_i / 100 \times W_i$
$MC_i$= initial moisture content of crop, %
$W_i$ = weight of the input crop, kg

- *Capacity of Machine (LPH)*

Capacity refers to the maximum output that can be possibly achieved. This is calculated using the quantity of apple juice that extractor obtains per unit time.

Capacity = Vf / Tt

Where,
Vf = volume of the extracted juice (Litre)
Tt = total operating time, hour

## III. RESULTS AND DISCUSSIONS

### *A. Juice Recovery & Extraction Efficiency*

The results obtained from the tests are presented in Fig. 3 and Fig. 4. It can be observed that juice recovery and extraction efficiency increased with the motor speed up to 2400 rpm. However, at the highest motor speed of 2600 rpm, the machine started to vibrate, resulting in lower juice recovery and extraction efficiency.

The extraction efficiency was highest at 2400 rpm, where juice recovery was 68.80% and extraction efficiency was 86.00% for a blade length of 4.5 cm. For a 6 cm blade length, the values were 73.60% for juice recovery and 92.08% for extraction efficiency. Both juice recovery and extraction efficiency were lower for the 4.5 cm blade compared to the 6 cm blade at various motor speeds.

Fig. 5 compares juice recovery of apple fruit for the two blade lengths, 4.5 cm and 6 cm. It shows that juice recovery for the 6 cm blade length was significantly higher than for the 4.5 cm blade. Juice recovery increased with motor speed, but at 2600 rpm, the motor's vibration caused reduced recovery. The highest juice recovery was observed at a motor speed of 2400 rpm.

Fig. 6 compares the extraction efficiency of apple fruit at the two blade lengths, 4.5 cm and 6 cm. It demonstrates that extraction efficiency for the 6 cm blade length was much higher than for the 4.5 cm blade. As the motor speed increased, extraction efficiency also increased. However, at 2600 rpm, the motor's vibration led to decreased efficiency. The highest extraction efficiency was observed at a motor speed of 2400 rpm.

### *B. Capacity of the Machine*

The results obtained from the tests are presented in Fig. 7. It can be observed that the capacity of the machine was highest (1.326 LPH) at a motor speed of 2400 rpm and a blade size of 6 cm. The capacity of the machine increased with the motor speed, but at the highest speed of 2600 rpm, the machine started to vibrate, resulting in reduced capacity.

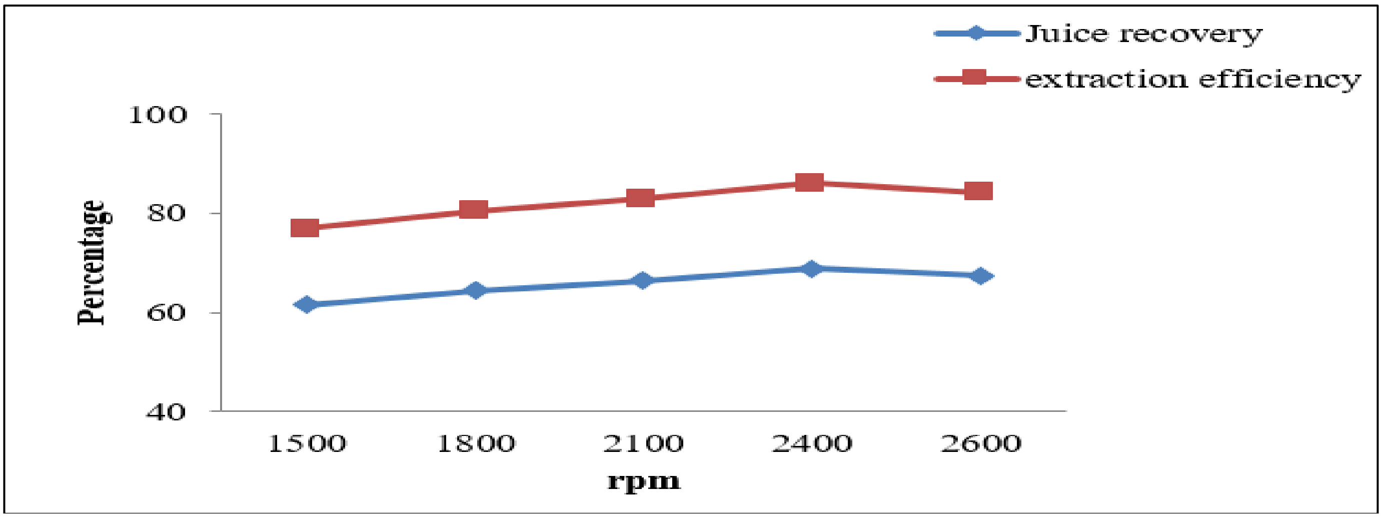


Fig 3: Juice Recovery and Extraction Efficiency for 4.5 cm Blade

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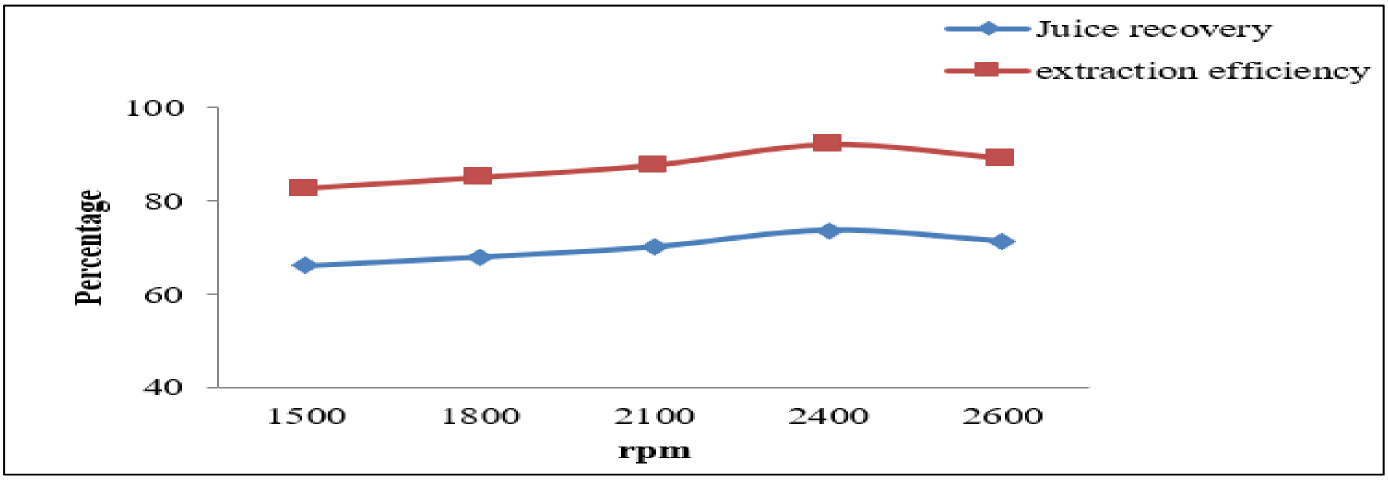


Fig 4: Juice Recovery and Extraction Efficiency for 6 cm Blade

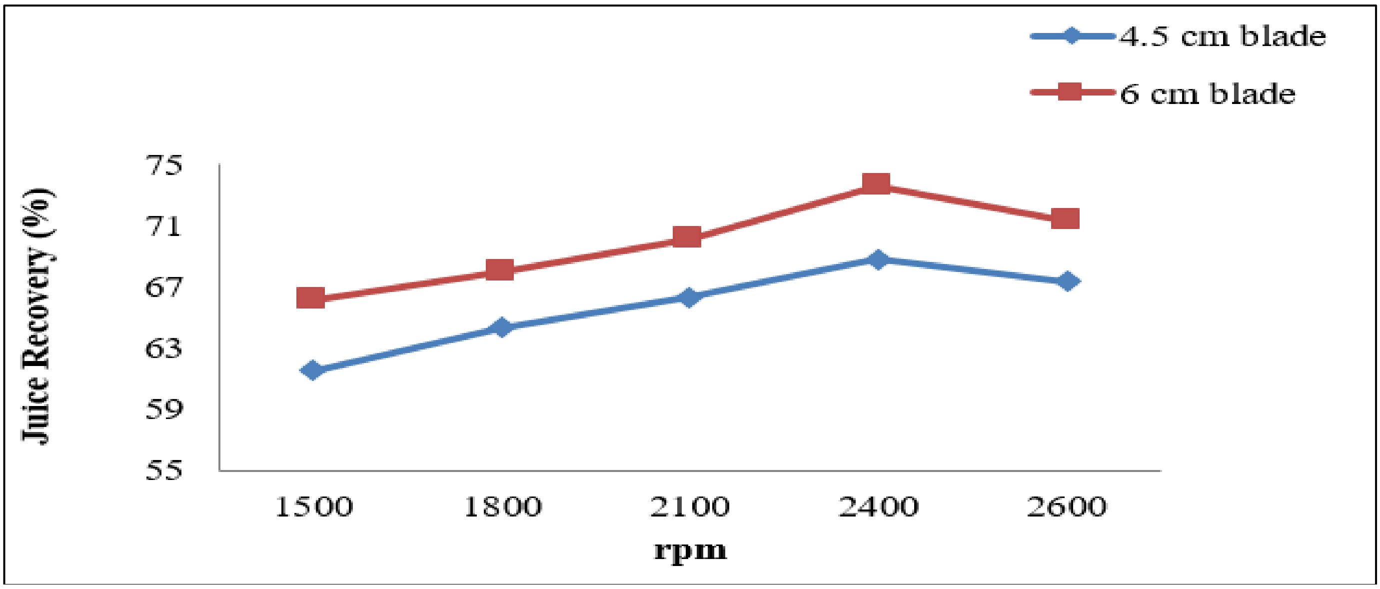


Fig 5: Comparison of Juice Recoveries

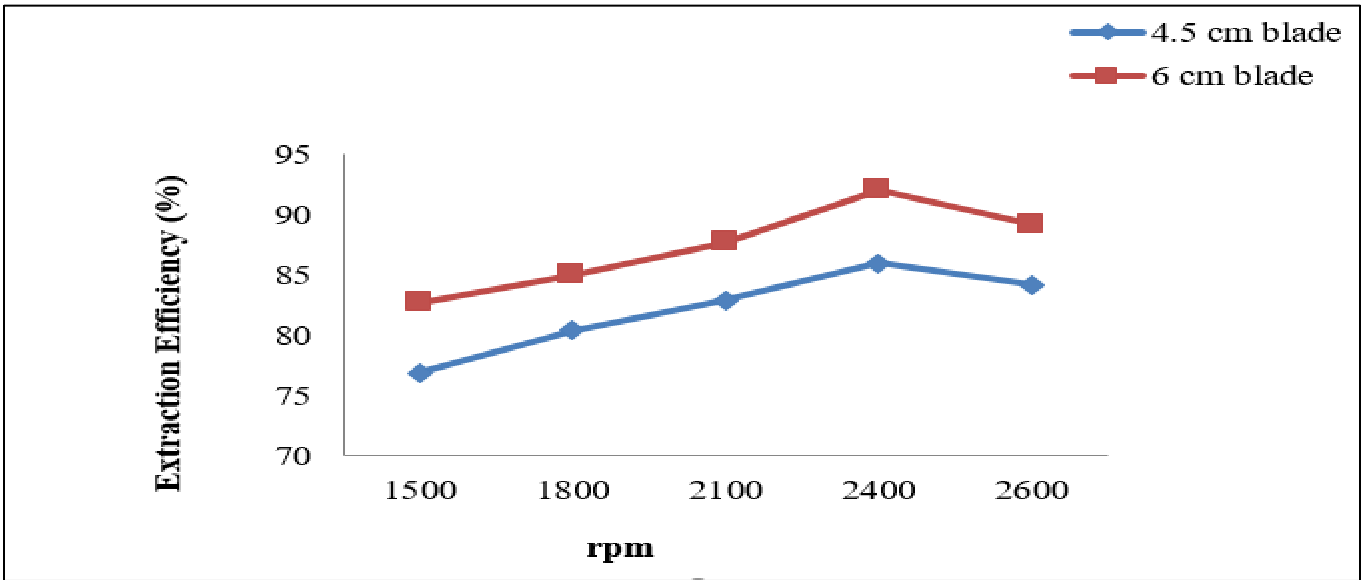


Fig 6: Extraction Efficiency

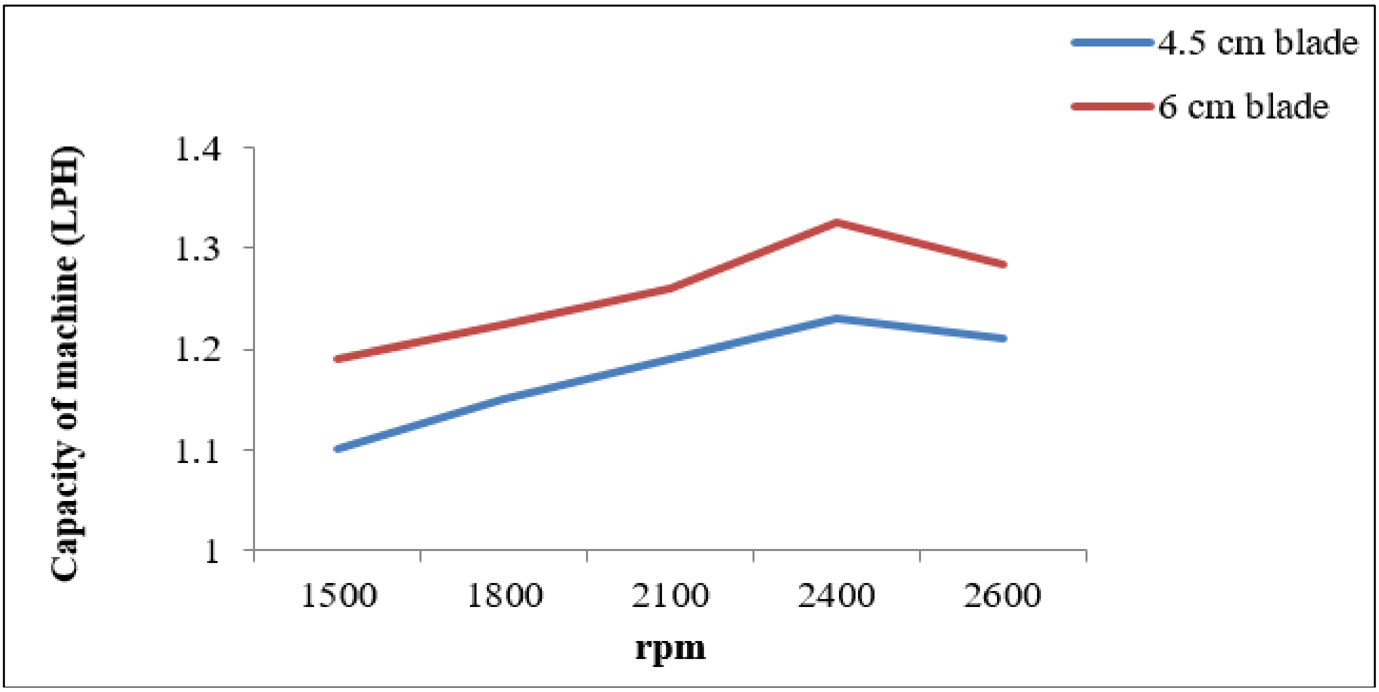


Fig 7: Comparison of Capacity of Machine

## IV. CONCLUSIONS

- A solar-based apple juice extractor can be developed using locally sourced, relatively cheap, and durable materials, including a plastic screw. This approach can reduce the fabrication cost by approximately 40 percent compared to commercially available models. Such a machine can be recommended for use by small-scale farmers and food processors.
- The maximum juice extraction efficiency of 92.08% and maximum juice recovery of 73.60% for the developed apple fruit juice extractor can be obtained at a motor speed of 2400 rpm, with a machine capacity of 1.326 LPH and a blade length of 6 cm.

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