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Fabrication and testing of a manually operated citrus juice extracting machine

Unuigbe Odion Michael[1☼], Olawepo Babatunde Bamidele[2], Imanogor Patrick Aromuegbe[1]

1.Department of Agricultural and Bio-Environmental Engineering Technology, Auchi Polytechnic, Auchi, Nigeria
2.Department of Mechanical Engineering Technology, Auchi Polytechnic, Auchi, Nigeria

☼**Corresponding Author:**
Department of Agricultural and Bio-Environmental Engineering Technology,
Auchi Polytechnic,
Auchi, Nigeria
Email: kamyuf@gmail.com

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ABSTRACT
This research work was centered on the fabrication and testing of a manually operated citrus juice extracting machine. During fabrication of the machine, considerations were given to material of construction, simplicity of operation, easy mechanisms of extraction of the juice and extruding of the chaff after extraction. Stainless steel was selected and used for the construction of the component part of the extractor. The two basic compartments of the extractor are the feeding compartment and the juice extracting compartment. Other component includes screw shaft, mainframe, juice sieve, press cage cylinder, crushing discs, and rotating

handle. The machine operates on the principle of shearing and compressive action for extraction to occur. Orange and tangerine fruit were used for testing of the machine. The juice extracted was filtered through the juice sieve into juice collector while residual waste is discharged by unscrewing the covering disc. The result of testing of the machine reflect that the machine operate at optimum extraction efficiency of 60 and 58% for orange and tangerine respectively.

Keywords: citrus fruits, extraction, juice, extraction efficiency, orange

1. INTRODUCTION

Citrus fruits commonly originated in tropical and sub-tropical regions of the world and belong to the family *Ructaceae* that are grown all over the world and have numerous therapeutic properties like anticancer, anti-tumor and anti-inflammatory. These properties are due to the phyto-vitamins and nutrients present in the citrus fruits. Citrus species also have an important role in herbal medicine .Citrus fruits are low in fats and proteins, but supply carbohydrates (sucrose, fructose, glucose) .Fresh citrus fruits act as rich source of dietary fiber. Citrus fruit are recognized as important components in human healthy life (Aslin, 2014). Fruits are important components of human diet because of the large contents of vitamins A, B, C and minerals like Calcium and Iron, which meets daily nutrients requirements and good health. Most fruits are seasonal in availability and highly perishable in natural states and fresh forms because of their high water content (70-90%) which aids chemical deterioration (Taylor, 1998). Fruit juice extraction methods in time past is crude, people apply pressure with hand and mouth during squeezing of the fruit in order to get the juice out of the fruit (for citrus and cashew) and other methods like peeling and eating raw (for fruits like pineapple, pawpaw and watermelon). These methods are primitive and consume both time and energy and the production is very low. Fruit juice production in rural and urban areas is essential to enable local farmers produce high quality and quantity of juice and reduce wastage of fresh fruits therefore, there is need for agricultural and food engineers, to produce affordable machines that will extract juice from fruits in their raw forms (Aremu, *et al.,* 2016).

Fruits are seasonal and therefore are not available in sufficient quantities throughout the year because it is difficult to store them in their natural form. The major problem is the high perishing rate of fresh fruits especially in the Sub-Saharan region (Olaniyan, 2010). A study carried out on fruits indicated that the losses were up to 30 % during the rainy season (Ndubisi *et al.,* 2013). This problem leads to scarcity as well as high cost of fresh fruits during the off-season. This has made it necessary for continuous research in ways to preservation of fruits. Extraction of the liquid content (juice) has been found to be one of the best methods for fruits preservation. Some fruit juices can take months or even years before they expire depending on how well they were preserved and packaged (Abulude *et al.,* 2007). In many areas they are plentiful but seasonal, thus expensive. An extractor from locally available materials is therefore necessary to effectively and efficiently extract juice from various fruit at a low cost so as to encourage fruit juice consumption for a healthy life. Extraction variables such as heat treatment and duration of treatment were reported to affect the colour, acidity and vitamin C content of cashew fruit juice however soluble solids, pH, and Specific gravity of the juice is not affected by heat treatment (Akinwale *et al.,* 2001). Smoot and Naggy (1980) reported that storage temperature and duration affects the total vitamin content of grape fruit juice (Miguel *et al.,* (2004).

Orange (*citrus sinensis*) is a dominant member of a large botanical family known as citrus. Other members of the family are tangerine (*citrus reticulata*), grape fruit (*citrus paradisi*), lemon (citrus limon) and lime fruit (*citrus aurantifoiia*). Orange is an economic crop in Nigeria and had long been planted in Lagos, Imo, Oyo and Benue states. The orange fruit is stored well on the tree and the ripe fruit utilized either as fresh fruit, processed into juice or frangrant peel. With a density of about 734 kg/m3, orange fruit is a rich source of vitamin- C (Olaniyan, 2010). Pineapple fruit (*Ananas Comosus*) is highly perishable in its natural state after harvest and is vulnerable to spoilage by mechanical damage, chemical deterioration and environmental effects. Pineapple never becomes any ripened than it was when harvested, though a fully ripe pineapple can bruise and rot quickly. It should be used within two days of harvest when kept at room temperature. However, it can span for a period of seven days when properly stored in a fridge. Fresh pineapple is low in calories. Nonetheless, it is a store house of several unique health promoting compounds, minerals, minerals and vitamins that are essential for optimum health. Pineapple contains a proteolytic enzyme, bromelain, which breaks down protein. Bromelain also has anti-inflammatory, anti-clothing and anti-cancer properties. Studies have shown that consumption of pineapple regularly helps fight against arthritis, indigestion and worm infestation. Though it contain small amount of vitamin A but is very rich in B complex. Thus, it is highly essential to process the freshly harvested fruit into juice which can be consumed fresh or processed further into healthy beverages (Badmus and Adeyemi, 2004).

Fruit juice extraction involves the process of crushing, squeezing and pressing of whole fruit in order to obtain the juice and reduce the bulkiness of the fruit to liquid and pulp. According to Abulude *et al* (2007), the various processes involved in fruit processing include: sorting, washing, pressing, slicing, crushing and extraction, addition of additives, homogenization, pasteurization (heat treatment), packaging and storage. There are two principal methods of juice extraction from fruits. In the first method, the fruits are crushed and pressed continuously in a single operation. In the second method, fruits are sliced into smaller pieces and then processed by a suitable pressing machine to extract the juice. The common types of juice extraction machines include: simple juicers, manual juicers and continuous juicers. Automatic juicers are sub-divided into centrifugal juicers and masticating juicers (Jackson, 1998). Efficiency of extraction process is a function of yield of juice obtained and time taken to obtain it. It depends on the following factors: Viscosity of juice to be removed; resistance of the formation of solid phase of pulp; porosity of pulp and pressure or force applied. These 10 factors are dependent on the physical characteristics of the pulp to be extracted and are subject to change in the course of extraction (Simmonds, 2000).

2. MATERIALS AND METHODS

2.1. Description of the machine

The machine (Figure 1) works based on the principle of shearing and compressive operation. During the operation of the extractor, the materials (citrus fruits) to be press is weighed using weighing balance and then introduced into the cylindrical cage already fixed on the frame through the hopper. The turning handle will then be used to screw the shaft through a nut and thereby shearing and compressing the fruit between the plates in the cage. When the extraction operation has been completed, the cake/chaff can then be extruded by losing the screw.

Figure 1 Pictorial View of the Juice Extractor

Figure 2 Pictorial Views of the Juice Extractor during Testing of the Extractor

2.2. Sample Preparation

The fruits to be used for testing the machine will be purchase in Uchi market Auchi, Edo State, Nigeria. The fruits after purchased were washed, peeled and weighed before introduced into the machine.

2.3. Testing Procedure

While testing the machine (Figure 2), orange of mass 0.42kg was weighed and introduced in to the extractor before the pressing operation begins. During pressing, the stopwatch was set in place to monitor the extraction time of the orange. After the extraction processes has been completed the juice and chaff were collected separately and weighed. The same procedure was repeated using tangerine.

2.4. Measurements and Calculations

2.4.1. Determination of Juice Yield

The juice yield is defined as the amount of juice recovered from certain kilogram of fruits and it can be expressed mathematically as:

$$JY(\%) = \frac{W_{JE}}{W_{JE}+W_{CK}} \times 100\% \qquad (1)$$

Where;

$JY = juice\ yield\ (\%)$
$W_{JE} = weight\ of\ juice\ extracted\ (g)$
$W_{CK} = weight\ of\ cake\ extruded\ (g)$

2.4.2. Determination of Juice loss

The juice loss is defined as the amount of juice wasted or unaccounted for at the end of extraction process and it can be determine using the expression below:

$$JL = \frac{W_{TS}-(W_{JE}+W_{CK})}{XW_{TS}} \times 100\% \qquad (2)$$

Where;

$JL = Juice\ loss(\%)$
$X = Juice\ content\ of\ the\ sample\ (\%)$ =39.18 and 41.25 respectively for orange and tangerine (Nelofer *et al*; 2015)
$W_{TS} = Total\ weight\ of\ sample\ (g)$

2.4.3. Determination of Extraction Efficiency

The extraction efficiency of the machine is defined as the optimum extracting capacity of the machine and can be determined mathematically as:

$$EE(\%) = \frac{W_{JE}}{XW_{TS}} \times 100\% \qquad (3)$$

Where;

$EE = Extraction\ efficiency\ (\%)$

2.4.4. Extraction Time

The extraction time covers the period of time that the juice start coming out of the sample till the time it stop coming out and this is determine with the aid of stop watch.

3. RESULTS AND DISCUSSIONS

3.1. Testing Result

The result obtained from the testing of the machine using oranges and tangerine is as shown on the Table 1.

Table 1 effects of extraction time on the extraction efficiency of the machine

Extraction time	Extraction Efficiency (%)	
	Orange	Tangerine
3	55	54
5	57	55
8	59	57
10	60	58

3.2. Effects of Extraction Time on the Extraction Efficiency of the Machine

The effects of extraction time on the extraction efficiency of the machine are shown on the figure below. The chart reflects that the extraction efficiency increases with increase in extraction time and the extraction efficiency obtained for orange is higher than that obtained for tangerine.

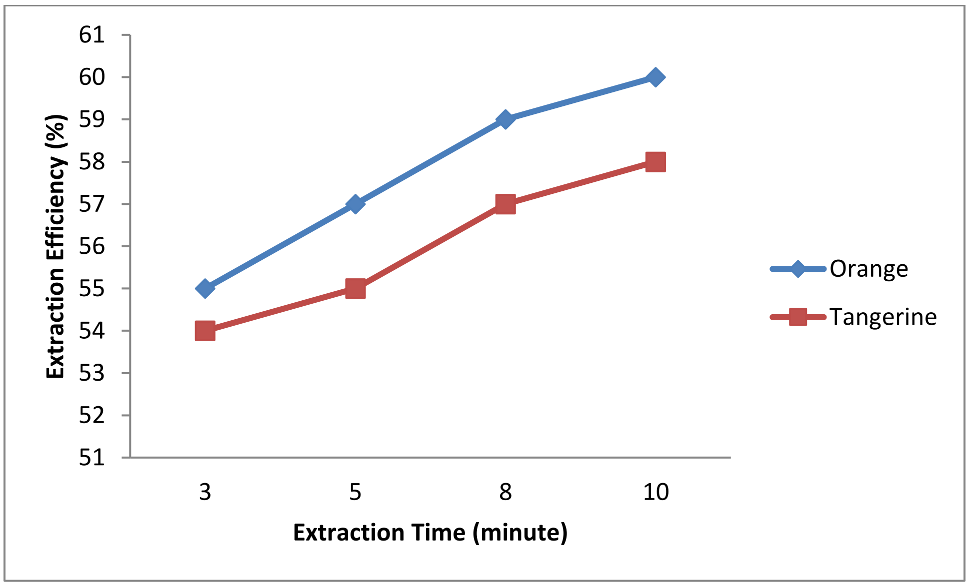

Figure 1 Effects of Extraction Time on the Extraction Efficiency of the Machine

4. CONCLUSION

A citrus juice extractor was fabricated and tested. The extractor was found capable of extracting citrus juice from fruits with an appreciating efficiency. The result of testing of the machine shows that the extraction efficiency of the machine is highly dependent on the extraction time and the extraction efficiency obtained from orange is higher than that obtained for tangerine using the machine.

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