International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 8 Issue 05 Series. II || May 2019 || PP 84-90

Production of Bioethanol from Selected Waste Fruits by Residual Thermal Enrgy Cogeneration Methods

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Abstract: *The availability of domestic natural gas and petroleum products cannot meet the high demand for these energy sources by the population. It is therefore, necessary to carry out research that can lead to producing energy from renewable sourcessuch asbiomass which are biodegradable and environmentally friendly. Improvement were made on the process of quantitative Bioethanol production from rotten fruits by residual thermal energy cogeneration method using Soxhlet and Rotary evaporator equipment. 3kg each of rotten orange, banana and pineapple were used. The results indicated that 500ml, andeach filtrate of the fermented fruit produced bioethanol of volume390.0±13.0 ml, 270.0±11.0 ml and 350.0±14.0ml representing 78% 54% and 70% bioethanol percentage yields for orange, banana and pineapple respectively with soxhlet equipment. While with rotary evaporator equipment, the volume and % yield of the Bio ethanol produced were 315.0±12.0 ml,230.0±11.0 ml and 255±11 ml with 63%, 46% and 51% respectively for orange, banana and pineapple.Orange has the highest % yield of the bioethanol produced in both soxhlet and rotary residual cogeneration methods followed by pineapple and banana. However, the process was found to be faster with pineapple and banana (150 min) than with orange (180 min) for the two equipment.It has been therefore suggested that the waste fruits of orange, banana and pineapple could be used for the production of bioethanol as an alternative energy source.*

Keyword;*Bioethanol, Fruits, Soxhlet , Rotary evaporator, Fermentation, %Yield.*

Date of Submission: 05-05-2019 Date of acceptance: 20-05-2019

I. Introduction

Bioethanol is among the most important renewable fuel materials that is ecofriendly contributing to reduction of environmental pollution generated due to the worldwide application and utilization of petroleum products. Combustion and utilization of fossil fuels that is currently going on would definitely contribute to the global environmental crisis. It is, therefore, necessary to carry out a research that can lead to production of this nature so as to source for renewable energy from biomass which is biodegradable and environmentally friendly [1] and [2] [3] .

As a result of high demand of petroleum products for generation of energy, production of the alternative means of energy such as Biofuel from different sources is of growing interest worldwide. Agricultural wastes such as fruit materials represent an abundant inexpensive and readily available biomass which are considered as waste are being disposed in many places and becoming a nuisance to our environment.

For a long period of time, it has become apparent that availability of domestic natural gas and petroleum products cannot meet the high demand for these energy sources. As a result, there has been serious concern for developing renewable energy sources so as to reduce the severity of the expected shortage. An alternative for this is the conversion of waste materials from agricultural products such as rotten fruits into liquid and gaseous fuels.

Presently, there are many countries that use waste biomass as an alternative for energy production. A typical example is the United States of America, which produces approximately three billion gallons of Biofuel from agricultural products. Other countries include Australia and Zimbabwe where substantial amounts of biofuel are being produced from agricultural waste materials,the most ambitious being that of Brazil that export 46.6% of U S demand of Biofuel [4] .

Different biofuels such as ethanol, methanol, bio-diesels, etc. are produced by fermentation of agricultural wastes, fruit wastes, municipal and industrial wastes using Saccharomyces Cerevisiae (baker's yeast) as food for the micro-organisms. Amongst these biofuels, ethanol has great demand as it is widely

accepted and it is clean burning [5]. In many countries, ethanol is used as either an alternate fuel or blended with petrol or gasoline. Many investigators have studied on the production of ethanol using various raw materials [6].The least expensive and easily available raw material for the production of bioethanol is fruit waste. It is a potential source, from which ethanol can be produced. Fruit waste which is discarded has great antimicrobial and cell reinforcement potential [7].

In Nigeria, substantial amount of the harvested bananas, oranges, pineapple and water melon are rejected as waste due to poor preservation techniques. This fruit waste that have been discarded are normally dumped as a huge masses of wastes, which ultimately cause contamination of water source as well as can affect the environment and health of living microorganisms. Thus, to avoid the environmental problem due to the decomposition of waste, it is usable to make energy from this waste as biofuel production source and animal feeds.The objectives of this study were to produce an optimum blueprint for the production process of ethanol from rotten fruits by residual thermal energy cogeneration method using Soxhlet and rotary evaporator equipment. In addition, to determine the amount of the produced biofuel and then compare the percentage yield of the product from each of the different rotten fruit samples.

II. Material and Methods

Materials

The raw materials used comprised of Banana, pineapple and orange wastes which were obtained from market dumpsite of Barnawa railway station Kaduna, Nigeria.

Sample Preparation

Three kilograms (3.0kg) of each sample was thoroughly washed with distilled water, cut with sterile knife, homogenized with sterilized electric juice blender. The mash obtained from each fruit sample was dispensed into a cleaned sterilized container and stored at 20^{o}c.

Fermentation

The starter culture medium was prepared by inoculating 20gm of saccharomyces cerevisiae in 100 ml of distilled water at 35^{o}c under static conditions in an incubator for a period of 24 hrs. The rehydrated and activated culture was added into each of the fermentation chambers under static condition of 30^{o}c and allowed to ferment for a period of 24 hrs. After the fermentation processes, a cleaned and sterilized cotton cloth was used for sieving the product from the residues. The extract from each fermented product was collected in different sterilized plastic containers and stored accordingly[8].

Distillation

To obtain a pure product of bio-fuel, the residual bio-fuel obtained after sieving was subjected to distillation process under vacuum at a relatively low temperature of 75^{o}c using cogeneration method with rotary evaporation system model RE – 52Aand Soxhlet equipment. In each case, distillation was carried out in batches and distillates were collected at different interval of time.

III. Results and Discussion

500 ml each of the filtrate of fermented Orange, Banana and Pineapple were used for the extraction of bioethanol using Rotary Evaporator and Soxhlet equipment. The corresponding volume of bioethanol extracted, percentage (%) yield and the time of extraction are presented in Tables 1-3.

Table 1.**Volume of Extracted Bioethanol, % yield and Time from 500ml of fermented Orange**

	Soxhlet Apparatus				**Rotary Evaporator**			
Time(min)	Volume(ml)	Cumulative Volume(ml)	Yield(%)	Cumulative Yield(%)	Volume(ml)	Cumulative Volume(ml)	Yield(%)	Cumulative Yield(%)
30	150±3.00	150	30	30	120±4.00	120	24	24
60	100±2.00	250	20	50	100±2.00	220	20	44
90	80±3.00	330	16	66	60±2.00	280	12	56
120	35±2.00	365	7	73	20±1.00	300	4	60
150	15±1.00	380	3	76	10±2.00	310	2	62
180	10±1.00	390	2	78	5±1.00	315	1	63

Table 2.Volume of Extracted Bioethanol, % yield and Time from 500ml of fermented Banana

	Soxhlet Apparatus				Rotary Evaporator			
Time(min)	Volume(ml)	Cumulative volume(ml)	Yield(%)	Cumulative Yield(%)	Volume(ml)	Cumulative volume(ml)	Yield(%)	Cumulative Yield(%)
30	90.0±3.0	90	18	18	70.0±2.0	70	14	14
60	70.0±3.0	160	14	32	60.0±2.0	130	12	26
90	60.0±2.0	220	12	44	55.0±3.0	185	11	37
120	30.0±2.0	250	6	50	25.0±2.0	210	5	42
150	20.0±1.0	270	4	54	20.0±2.0	230	4	46

Table 3.Volume of Extracted Bioethanol, % yield and Time from 500ml of fermented Pineapple

	Soxhlet Apparatus				Rotary Evaporator			
Time(min)	Volume(ml)	Cumulative Volume(ml)	Yield(%)	Cumulative Yield(%)	Volume(ml)	Cumulative Volume(ml)	Yield(%)	Cumulative Yield(%)
30	112±4.00	112	22.4	22.4	80±3.00	80	16.0	16.0
60	91±3.00	203	18.2	40.6	73±3.00	153	14.6	30.6
90	70±3.00	273	14.0	54.6	64±3.00	217	12.8	43.4
120	52±2.00	325	10.4	65.0	23±1.00	240	4.6	48.0
150	25±2.00	350	5.0	70.0	15±1.00	255	3.0	51.0

Orange

The total volume of ethanol extracted from 500 ml of fermented orange at 75ºc using soxhlet apparatus was 390.0± 13.0 ml in 180 min, the highest volume extracted was 150.0 ml±3.0 ml in the first 30 minute while 10. 0 ± 1.0 ml was extracted in the last 30 minute. The total % yield of ethanol was 78% with 30% yield in the first 30 minute and 2% in the last 30 minute. with the rotary evaporator at 75 ºc the extracted volume of ethanol was 315. 0 ± 12.0 with 120. 0 ± 4.0 ml in the first 30 minute and 5.0±1.0 ml in the last 30 min. The total yield was 63% with 24% in the first 30 minute and only 1% was extracted in the 30 minute. The rate of ethanol extraction using the rotary evaporator was 1.75 ml/minute. Figure 1 and 2 compared the volume and % yield of extracted ethanol using both rotary evaporator and Soxhlet apparatus. The result reveals that Soxhlet apparatus extract more volume of ethanol than in the rotary evaporator at the same condition.

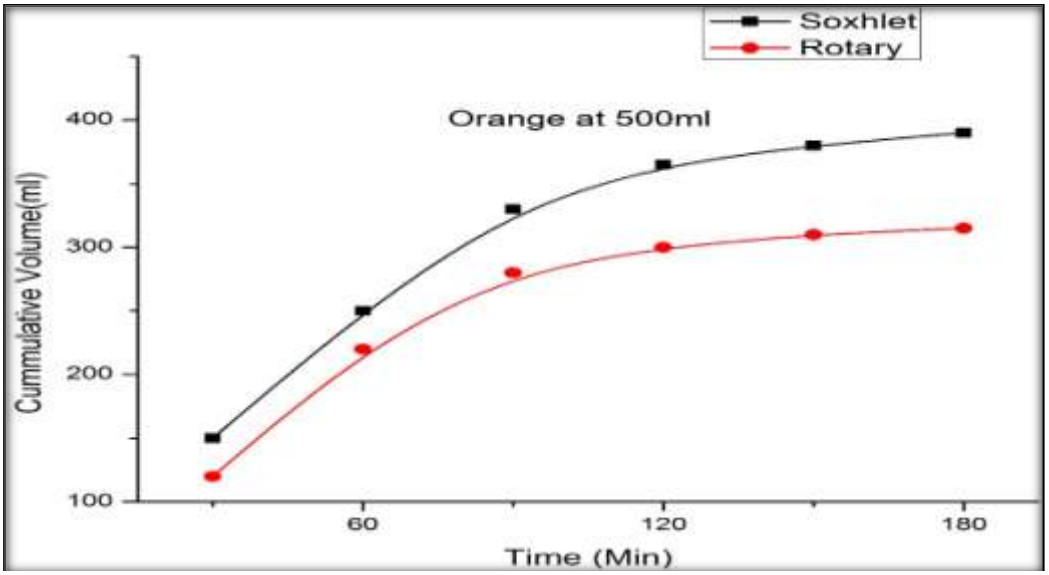

Figure 1: Cumulative Volume of Bioethanol Produced Vs Time for Soxhlet and Rotary

From Orange

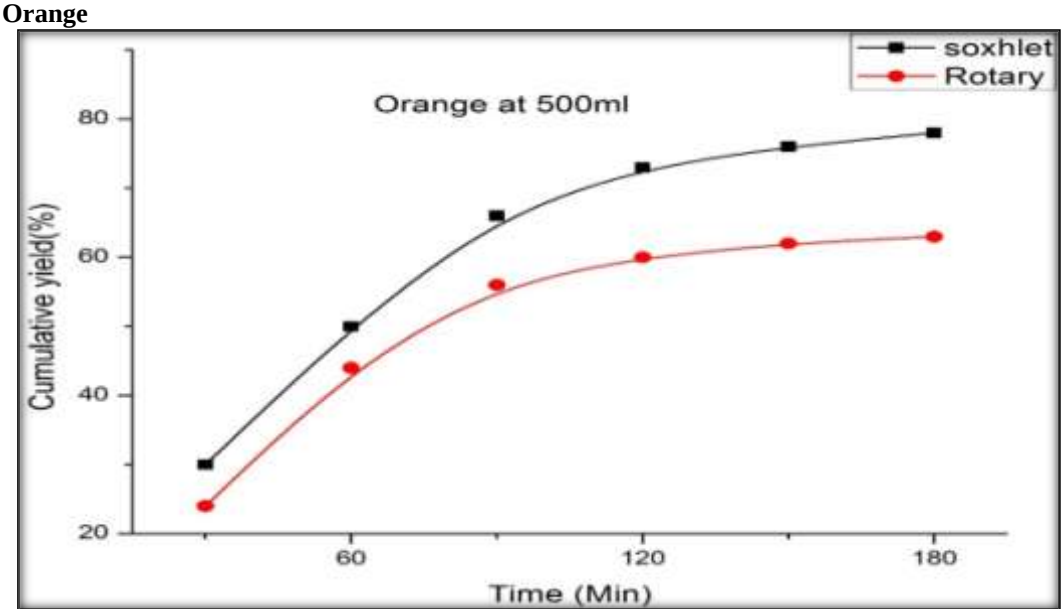

Figure 2: Cumulative% yield of Bioethanol Produced Vs Time for Soxhlet and Rotary From Orange

Banana

The total volume of ethanol extracted from 500ml of fermented Banana filtrate using Soxhlet was 270.0± 11.0 ml with 90.0± 3.0ml in the first 30 minutes while 20.0± 1.0ml was extracted in the last 30 minutes. Unlike orange the total timing was 150 minutes. the percentage yield was 54% out of which 18% yield was during the first 30 minutes. The extraction rate for Banana using Soxhlet apparatus was 1.8 ml/min. Similarly, the volume extracted from 500 ml of fermented Banana filtrate at 75ºc using Rotary evaporator was 225.0±11.0ml with 70.0±2.0mlin the first 30minutes and 20.0±2.0ml in the last 30minutes. The percentage yield was 46% with 14% and 4% in the first and last 30 minutes respectively. The extraction rate in rotary evaporator was 1.53 ml/min using the two types of apparatus. The result also indicates that the Soxhlet method gives higher value of yield than the rotary evaporator.

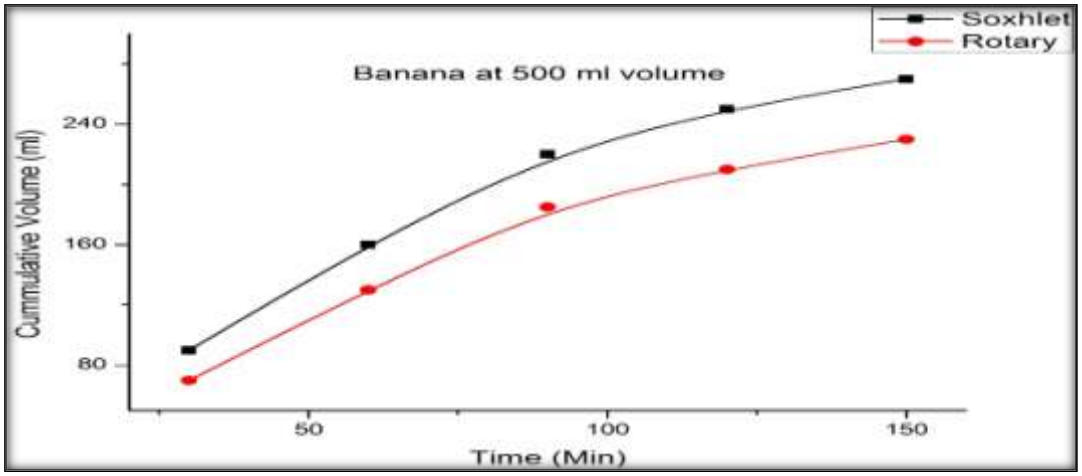

Figure 3: **Cumulative Volume of Bioethanol Produced Vs Time for Soxhlet and Rotary From Banana**

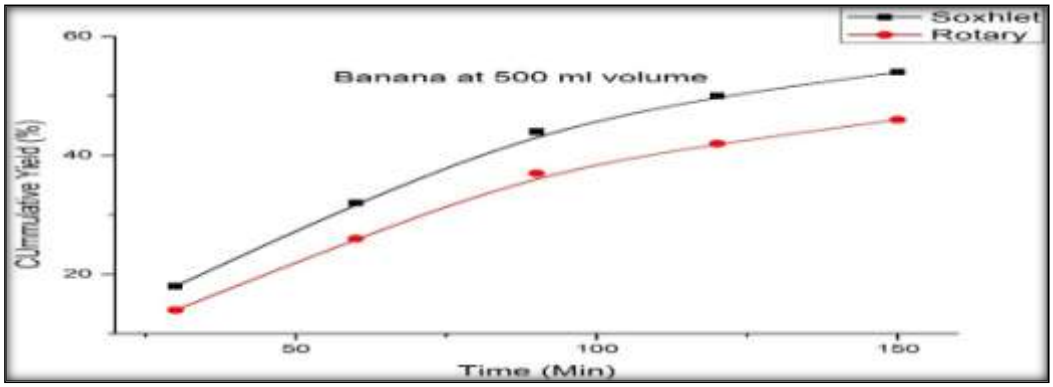

Figure4: Cumulative% yield of Bioethanol Produced Vs Time for Soxhlet and Rotary From Banana

Pineapple

The amount of bioethanol extracted from 500ml of fermented pineapple filtrate using Sochlet apparatus way 350.0±15.0ml with 112.0 ± 4.0ml and 25.0 ± 2.0 ml at the first and last 30 minutes respectively as shown in Table 3. The total percentage yield was 70% with 24% yield during the first 30minutes of extraction and 51% yield during the last 30minutes. The extraction rate in Soxhlet was 2.4ml/min. The volume bioethanol extracted using rotary evaporator was 255.0 ± 11.0 ml with 80%yield and 15.0 ± 1.0 ml during first and last 30minutes of extraction respectively. The rate of extraction with rotary is 1.7ml/min. figure 5and 6 compared the volume and percentage yield of the extract using the two methods respectively.

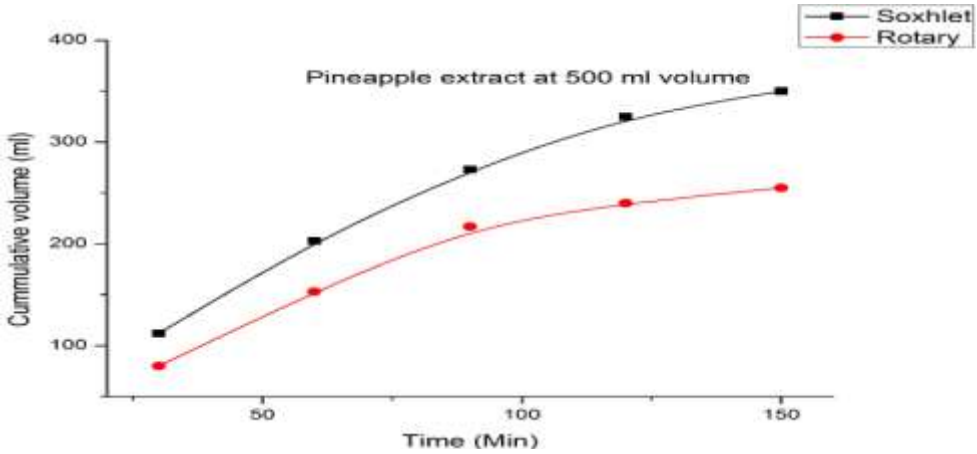

Figure 5: Cumulative Volume of Bioethanol Produced Vs Time for Soxihlet and Rotary From Pineapple

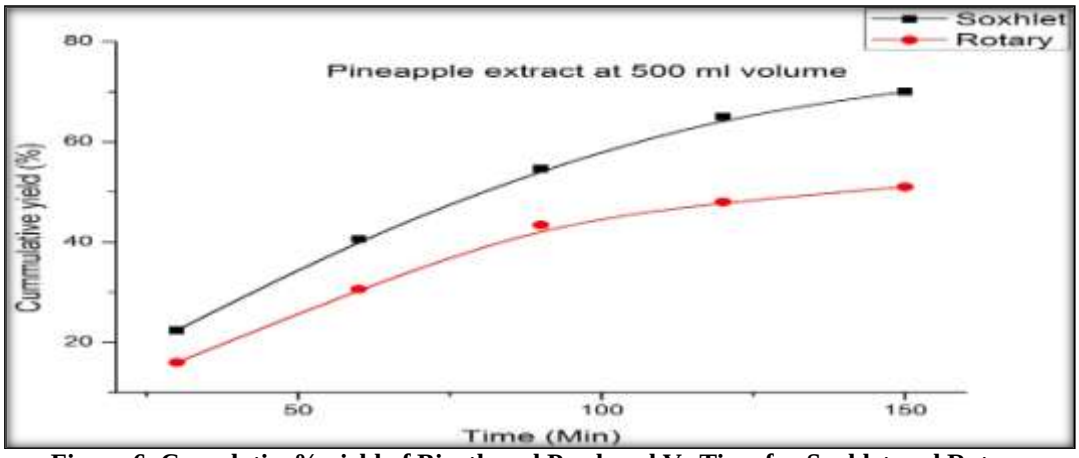

Figure 6: **Cumulative% yield of Bioethanol Produced Vs Time for Soxhlet and Rotary From Pineapple**

The volume and percentage yield of ethanol were higher with Soxhlet apparatus. Similarly, orange has the highest volume of ethanol extracted followed by pineapple while Banana has the lowest value as shown in figures 7 and 8 respectively. However, the extraction time is longer with respect to orange (180min) than those of Banana and Pineapple. (150 min). The result presented in this study compare favorably with those obtained by Cutzu and Bardi,2017 which shows the % yield of 43.40% ,89.59% and 45.06% for apple, kiwifruit and peach respectively with process period of 192min and temperature of 80 ^{0} C using rotary equipment.

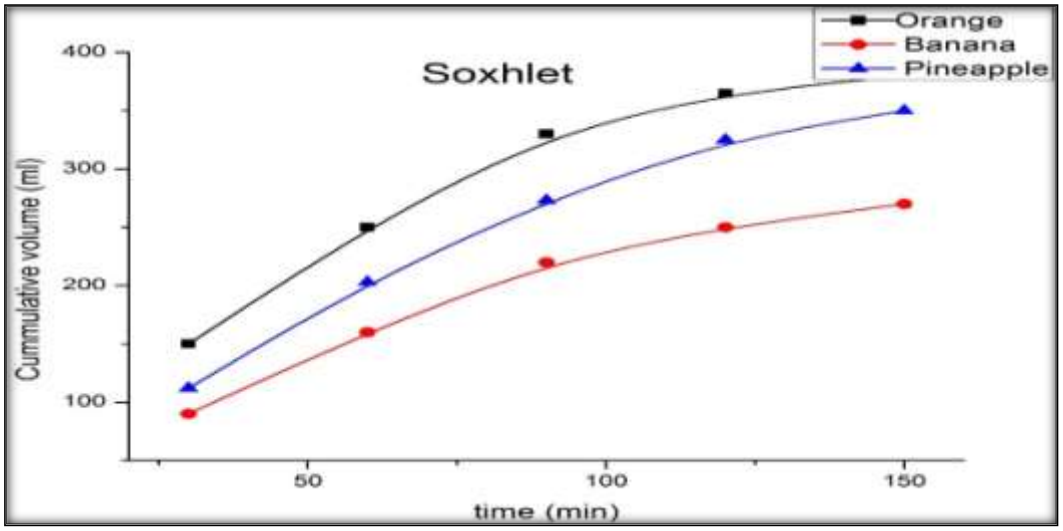

Figure 7: Cumulative Volume of Bioethanol Produced Vs Time for Soxihlet From Orange, Banana and Pineapple

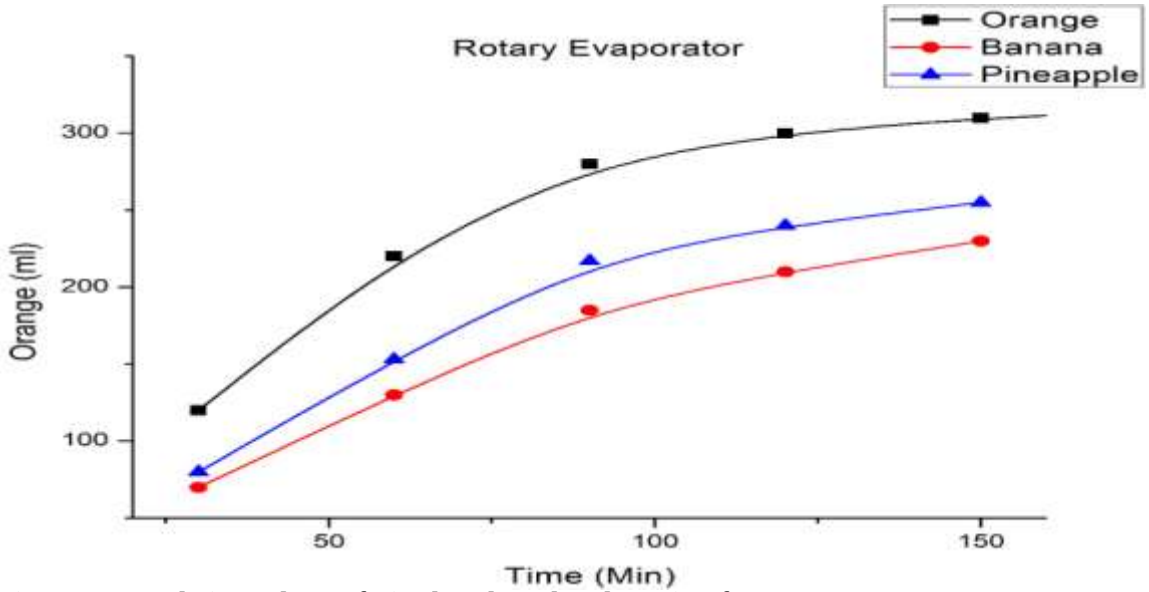

Figure 8: **Cumulative Volume of Bioethanol Produced Vs Time for Rotary Apparatus From Orange, Banana and Pineapple**

IV. Conclusion

Inthis study the processes of biofuel production from the rotten fruits were developed using 3kg of each by soxhlet and rotary evaporator equipment. Rotten orange, banana and pineapple were used as raw materials. 500ml of the filtrate of the fermented fruits were used for the Bioethanol production with rotary and soxhlet equipment. The result shows that 500ml of filtrate of thefermented orange take 3 hours (180min.) at 75^{o}C for the process in both soxhlet and rotary equipment to complete. While 500 ml each of the filtrate of fermented banana and pineapple takes 2 and half hours (150 min) at 75^{o}C for the process to completein both soxhlet and rotary equipment. The volume of the bioethanol produced and percentage yield using soxhlet equipment were 390.0±13.0ml (78%), 270.0±11,0 ml (54%) and 350.0±14.0 ml (70%) for orange, banana and pineapple respectively.The volume and % yield using rotary equipment were 315.0±12.0 ml (63%), 230.0±11.0 ml (46%)

and 255.0±11.0 ml (51%) for orange banana and pineapple respectively. The percentage yield is higher in orange then followed by pine apple, while banana has the lowest percentage yield for both soxhlet and rotary equipment. However, the process is faster with banana and pineapple than with orange. The % yield for the 3 fruits is higher in soxhlet than in rotary equipment

Acknowledgement

We wish to sincerely appreciate the contributions ofTertiary Education Trust Fund, the Management of Kaduna Polytechnic and theChairman and Members of RITOCommittee forsponsoring this study, supervising andencouragement.

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Mohammed, S.S" Production of Bioethanol from Selected Waste Fruits by Residual Thermal Enrgy Cogeneration Methods" International Journal of Engineering Science Invention (IJESI), Vol. 08, No. 05, 2019, PP 84-90