International Journal of Academic Research and Development
www.academicjournal.in
ISSN: 2455-4197
Received: 20-07-2022, Accepted: 07-08-2022, Published: 22-08-2022
Volume 7, Issue 4, 2022, Page No. 35-44

Extraction of sucrose syrup of optimal mix of corn stover, sugarcane waste and bambara groundnut chaff using bioreactor

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Abstract
The study of sucrose extraction from the optimal mix feedstocks; Corn stover, sugarcane waste and Bambara groundnut chaff by enzymatic hydrolysis was carried out. The proximate and compositional analysis of the feedstocks were done to determine the viability of each feedstock for sucrose production. Hydrogen peroxide solution (2.5%) was used for delignification pre-treatment of the feedstocks and optimal mixing ratio of the feedstocks was determined for maximum sucrose yield and recorded as (1:3:1) of corn stover, sugarcane waste and Bambara groundnut chaff. Effect of process parameters such as temperature, time, enzyme concentration, and pH were investigated and optimized using central composite design of response surface methodology. The kinetics of the enzymatic hydrolysis of the mixed feedstock was studied using michaelis-menten models. The results obtained showed that all the feedstock contained both cellulose, hemicellulose and lignin in quantities recommended for Sucrose production with cellulose being dominant. It was observed that the yields of sucrose increased as the parameters increased up to certain levels before decreasing. The optimal conditions obtained from the enzymatic hydrolyzed mixed feedstock are hydrolysis temperature of 35oC, enzyme concentration of 8g/50mol, contact time of 5days and pH of 5.5 with sucrose yield of 71.41%. The kinetic model of the enzymatic hydrolysis of the mixed feedstock agreed with the Michaelis-Menten model with activation energy of 11.267KJ/mol. This study has shown that corn stover, sugarcane waste and Bambara groundnut chaff mixed in the ratio of (1:3:1) can serve as an alternative raw material for the Sucrose production industries in Nigeria and the kinetic data can be used in the design of process equipment for large scale production.

Keywords: extraction, sucrose syrup, optimal mix and bioreactor

Introduction
Lignocellulosic biomass is an abundant, inexpensive and readily available source of fermentable sugars (Ho *et al*., 1998). For the last few decades, the conversion of these resources into Sucrose and other reducing sugars has been considered as an attractive route for production of ethanol or other valuable chemicals (Curreli *et al*., 1997; Gaspar *et al*., 2005) [2, 4]. A wide array of biomass sources, including agricultural residues such as corn stover, wheat and rice straw and forestry residue; industrial residues such as pulp and paper processing waste and energy crops such as switchgrass have been employed as biomass source. However, unlike starch, which contains homogenous and easily hydrolyzed biopolymers, lignocellulosic plant matter contains cellulose (23-53%), hemicellulose (20-35%), and polyphenolic lignin (10-25%). Sucrose, obtained from lignocellulosic material, is usually expected to be a renewable source, which can be efficiently converted into fuels, foods, and other valuable chemicals (Huber *et al*., 2006) [5]. Cellulosic conversion into Sucrose therefore is a key process which needs to be further studied.
Nigeria's has a high demand for industrial fermentable sugars. This has continued to push the prices of such materials used for sourcing of fermentable sugars substrate higher up. While much attention has been devoted to starch and sugar conversion to fermentable sugar, little attention has been given to naturally occurring agricultural wastes in our environment as a source of alternative fuel. Production of hydrolysable table sugars from biodegradable plant materials (lignocelluloses) for the purpose of conversion to bioethanol (energy) or other industrial useful end products is a profitable alternative pathway. The constant practice of indiscriminate bush burning causes environmental pollution. Therefore, the conversion of agricultural waste to environmentally useful products is of utmost importance. Though local utilization of lignocelluloses raw materials have mainly been on energy production for the local people. Such practice have led to inefficient utilization of such resource and environmental pollution. It is also not socially and economically acceptable, hence not sustainable.
This therefore necessitates a thorough research on alternative uses from agricultural products of value industrial products such as fermentable sugar. Sucrose is a disaccharide known as it is an organic compound composed of monosaccharide of Sucrose and fructose. That is to say that, sucrose is made p of one molecule of Sucrose and one molecule of fructose joined together. Also, it is disaccharide molecule composed of two monosaccharide of Sucrose and fructose. Sucrose is a carbohydrate sugar that has chemical or molecular formula of

$C_{12}H_{22}O_{11}$.Sucrose is obtained from sugar cane or sugar can beets, fruits, plants and vegetables. Three substrate or feedstock were used for this research work and they include: Corn stover, sugarcane waste and Bambara Groundnut chaff. They were mixed in a total weight of 150g in a ratio of 1:3:1 of corn stover 30g, sugarcane waste 90g and Bambara groundnut chaff 30g.

The Potential uses of sucrose syrup are as follows;
- Sucrose is a white refined sugar used as a domestic sweetener.
- It is used as reagent in pharmaceutical industries.
- Sucrose is also used as preservatives and flavouring in confectionery.
- It is also sued as preservatives in foods manufacturing industries.
- Sucrose is used for production of Bio – ethanol.
- The characteristics of Disaccharide
- Sucrose is soluble in water
- It must be broken down into monosaccharides before they can be absorbed into the body. Examples of disaccharides carbohydrate are:
- Sucrose is known as table sugar.

Chemically, sucrose (molecule) = Sucrose (molecule) + Fructose (molecule).

Cellulose with chemical formula ($C_6H_{10}O_5$) belongs to group of polysaccharide carbohydrates. Chemically, cellulose consists of long chain of Sucrose (a monosaccharide) molecules.
The characteristics of cellulose include:
It forms the structure of some plants.
It is indigestible by humans but digestible by some other animals.
It is valuable in human diet as source of dietary fibre which used to be known as roughage. After pretreatment, the cellulose is prepared for hydrolysis, the molecules is cleaved by addition of water molecule and enzymatic hydrolysis equation is $(C_{12}H_{20}O_{10})\ n+nH_2O\ nC_{12}H_{22}O_{11}$ →

Bio-Chemical Processes
The extraction of sucrose syrup from the substrates or feed stocks passed three production processes namely: Collection of feedstocks, pretreatment and Enzymatic Hydrolysis.

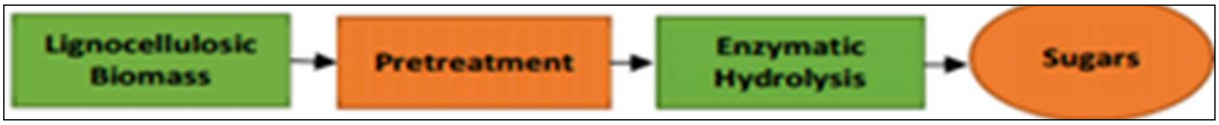

Fig 1: Biochemical Process of Production of Sucrose.

Materials and Methods
Materials
The Lignocellulose materials used include:
- Corn Stover
- Bambara Groundnut
- Sugarcane Waste

Sample Collection
Enugu state is among the major states in South-Eastern Nigeria. It is located within latitude $6^o.00^1$N and $7^o.00^1$N and longitude $7^o.00^1$E and $7^o.45^1$E. The plants used in this research study were obtained from within the state and transported to the laboratory for analysis.

Apparatus, Instruments and Chemicals Used
- Electronic devices used include:
- Bioreactor Machine
- Laboratory hot plate (DB 11A) and Thermometer
- Electrical Shaker and Autoclave machine
- Industrial Oven and Incubator
- Water bath (Precision instruments)
- pH meter manufactured by Metler Toledo (seven compact series).
- Digital refractometer manufactured by Hanna Instruments, Romania.
- Digital Heating Mantle manufactured by Metler Toledo
- Atomic Adsorption Spectrophotometer (Buck Scientific, 210VGP, USA)
- Weighing Balance (Seven Compact Series, Metler Toledo, Switzerland)
- Digital water bath (Precision Instruments) and UV / Visible Spectrophotometer (Perkin Elmer)

All reagents used are analytical grade (Sigma Aldrich Scientific) reagents and include:
- Calcium hydroxide.
- Phosphoric acid.
- *Sacheromycescerevisae* (Baker's yeast).
- 3- 5- dinitrosylicalic acid (DNS).
- Sodium potassium tartrate.
- Sulphuric acid.

All glass wears used were manufactured by Pyrex and include:
- Simple distillation system, made up of a 500ml round bottom flask, liebeng condenser and 250ml conical flask.
- Measuring cylinder (200ml and 10ml), Petri dish Test tube
- Beaker (100ml and 1000ml), Pipette (25ml), Burrete (100ml) and Flat bottom flask (500ml)

Other items used include;
- Muslin sieve and Plastic funnel.
- 100ml plastic bottles, Spatula, Masking tape and Distilled water
- Drip tube, Whatman filter paper and Porcelain crucible
- Flash Point Apparatus, Distillation Apparatus and U-Tubes Capillary Viscometer.

Methods

Sample Collection and Preparation

Bambara Groundnut Chaff, Corn Stover and Sugarcane waste were collected from agricultural waste disposal site in Enugu metropolis. The collected agric waste materials were properly cleaned to remove impurities. They were dried in laboratory hot air oven (Gallen Kamp, model OV -160, England) to remove final moisture to stable weight and finally ground using ball mill to fine particles. The oven-dried material were screened through a 250 µm mesh to obtain a fine biomass and packed in polyethylene-sealed bags prior to analysis.

Proximate Characterization

The proximate analysis were done using standard procedure of the Association of Official Analytical Chemists. The parameters of the substrates were analyzed using standard analytical procedures. These methods are elucidated below:

Crude Protein

The distillation flask was heated at 100^0C using a heating mantle to distil ammonia over into the boric acid solution. Distillation was discontinued when about 300ml of the digest solution has distilled over. The distillate were titrated with 0.1M sulphuric acid solution until solution returns to the colour before distillation.

$$\%\ Protein\ = \frac{Titrevalue \times 0.0014 \times conversionfactor(6.25) \times 100}{sampleweight} \quad [1]$$

Energy Content (Calorific Value)

Energy content of the products was calculated by Atwater's method.

$$Calorificvalue = (protein \times 4 + carbohydrate \times 4 + fat \times 9) \quad [2]$$

Bleaching (Lignin Removal)

The whole solution contained in the flask fitted with the condenser is refluxed at 90^0C for 150 minutes for complete lignin extraction. The solution was allowed to cool and filtered using a Whitman filter paper. It is also washed with hot water to neutralize the residue and it was allowed to dry at 50^0C in hot air oven

$$\%\ \text{lignin} = \frac{Initial\ weight - final\ weight}{intial\ wt} \quad [3]$$

Cellulose

The cellulose content, was calculated by difference, assuming that extract, hemicellulose, lignin, ash, and cellulose are the only components of the entire biomass (Lin *et al*., 2004, and Lin *et al*., 2010).

$$\%Cellulose = 100 - (\%\ ash\ +\ \%\ hemicellulose\ +\ \%\ Lignin\ +\ \%\ extractives) \quad [4]$$

Pretreatment Process

Alkaline peroxide pre-treatment was done according the method of Diaz *et al* (2013).

1 kg of ternary lignocellulose composite was fed into the hydrolysis chamber of the bioreactor. 2.5% hydrogen peroxide solution was introduced into the chamber to submerge the lignocellulose composite. The bioreactor which was thermostatically regulated was allowed to heat at 90 ºC for 2 h immediately after the set time, the solid residue was collected by filtration, washed thoroughly with hot water until neutral pH of the filtrate is achieved. The residue] (cellulose) was dried at 60 ºC.

Enzymatic Hydrolysis

After pretreatment, the sample was introduced into the hydrolysis chamber. Sample and water mixture was inoculated with known concentration of *Aspergillusniger* and kept at diverse temperatures for varying time interval and at different pH. The mixture was filtered and the reducible sugar yield was determined using the dinitrosalicylic acid (DNS) technique

Effects of Different Operating Parameters on Hydrolysis

In separate runs, the effect of substrates concentration, pH, reaction temperature, dosage of *Aspergylusniger* and reaction time were studied as follows:

Effect of pH

The pH of each substrate was varied between 4, 5, 6, 7 and 8, using mild concentrations of sodium hydroxide and hydrochloric acid as modifying media. All other reaction conditions were kept constant.

Effect of *Aspergillusniger* concentration

Fermentation was carried out at different A. niger concentration of 0.2% (w/v), 0.4% (w/v), 0.6% (w/v) and 0.8% (w/v) at constant substrates concentration and constant yeast concentration (Highina *et al*., 2006). Other conditions were kept constant.

Effect of temperature

The experiment were carried out at different temperature of 25^0C, 30^0C, 35^0C, 40^0C and 45^0C using the incubator for 5days at different temperatures. Other parameters were held constant (Omemu *et al*., 2005) [6].

Time

For the purpose of the experiment, hydrolysis time were varied for 1, 2, 3, 4, 5 and 6 days. All other variables remained constant.

Determination of Optimal Mixing Ratio of the Feedstocks.

The optimal mixing ratio of each pretreated feedstock in the sample were determined by varying the percentage of each feedstock in the 150g total mass of the sample hydrolyzed in the following order; (corn stover: sugarcane waste: Bambara groundnut chaff) as shown in the Table 2. Each mixed sample were enzymatically hydrolyzed and their sucrose yield recorded accordingly. Table 2 shows the ultimate analysis of some specimen and the result of H_2O_2 the pretreatment of the feedstocks for lignin respectively.

Table 1: Determination of Optimal Mixing Ratio of the Feedstocks.

Feed Stocks Mixing Ratio				
Sample	**Corn Stover**	**Sugarcane waste**	**Bambara groundnut chaff**	**Sucrose yield**
1	1	1	1	
2	2	1	1	
3	1	2	1	
4	1	1	2	
5	3	1	1	
6	1	3	1	
7	1	1	3	
8	2	3	1	
9	3	2	1	
10	1	2	3	
11	1	3	2	

Determination of Sugar Yield ByDns (3- 5- Dinitrosylicalic Acid) Method

Reagents Preparation

0.5g DNS was diluted in 30ml 2M sodium hydroxide solution. 150ml of saturated sodium potassium tatrate was prepared (90g of salt in 150ml of distilled water). The alkaline DNS solution was mixed with 75ml sodium potassium tartrate solution and stirred to dissolve properly. 45ml of distilled water was mixed with the solution so that the whole solution was made up to 150ml.

Sucrose/Sugar Determination

1ml of hydrolyzed sample was introduced into a test tube. 3ml of alkaline DNS was introduced into the sample and heated in water bath at 100^0C for 5 minutes for colour development. The samples were allowed to cool and 1ml of saturated sodium potassium tartrate solution was introduced to it and properly mixed. The samples were read in uv/visible spectrophotometer at wavelength 575nm.

Also, standard Sucrose solution at concentrations 0.5g/50ml, 1.0g/50ml, 1.5g/50ml, 2.0g/50ml and 2.5g/50ml, prepared and absorbance determined using the method above. The values obtained were used to plot Sucrose concentration and absorbance standard graph.

Results and Discussion

Characterization of Corn Stover, Sugarcane Waste and Bambara Groundnut Chaff

Table 2 shows the proximate composition of the Corn Stover, Sugarcane Waste and Bambara Groundnut Chaff samples. The samples were observed to have relatively low moisture content of 6.42%, 8.21% and 9.31%. Zakir*et al* (2016) reported the moisture contents of Corn Stover and sugarcane waste as 6% and 8% respectively.

On dry matter basis, 5.06%, 3.18% and 4.21% protein content were obtained for the Corn Stover, sugarcane waste and Bambara groundnut chaff samples. In this study while Pasakorm *et al* (2016) got 4.0% and 3.0% protein content on dry matter basis in Corn stover and sugar cane waste. The variation in the protein content could be as a result of the species used.

Also the proximate analysis of the Corn stover, Sugarcane and Bambara groundnut chaff shows that they contained cellulose and the percentage cellulose yield obtained are 43.3%, 51.03% and 40.30%. This implies that they are good substrate for sucrose production. Ebabhi *et al*. (2013) obtained 57.3% cellulose from the enzymatic hydrolysis of Plantain Peels.

The portion of the feedstock that are carbohydrates are the cellulose and hemicellulose biopolymers. The total carbohydrate content of the feedstock; corn stover, sugarcane and Bambara groundnut chaff were obtained to be 58.37%, 65.02% and 52.21% which represents a valuable source of sugars.

Table 2: Proximate analysis of Corn Stover, Sugarcane Waste and Bambara Groundnut Chaff

S/N	Proximate Analysis	Composition (%) Corn Stover	Composition (%) Sugarcane Waste	Composition (%) Bambara Groundnut Chaff
1	Protein	5.06	3.18	4.21
2	Ash	4.93	2.92	3.61
3	Fiber	24.74	21.34	26.71
4	Lipid	3.18	4.23	2.91
5	Moisture	11.42	10.21	12.31
6	Carbohydrate	58.37	65.02	52.21
7	Cellulose	43.3	51.03	40.30
8	Hemicellulose	20.06	24.89	18.98
9	Lignin	16.48	18.01	15.10
10	Extractive	4.96	3.23	3.01

Results of Hydrogen Peroxide Pre-Treatment of the Feedstocks for Lignin Removal

The removal of lignin is necessary for cellulose to become readily available for the enzymes for asccharification, which permit the yeast to convert the Sucrose into ethanol Wyman, 1996. In the present study the delignification was done with the pre-treatment of feedstock with H_2O_2 in alkaline condition as described in the pretreatment process.

The effect of H_2O_2 pre-treatment of Corn stover, Sugarcane waste and Bambara groundnut chaff in alkaline solution on lignin removal is shown in Fig. 2.

It shows that the pre-treatment of all the raw materials with 2.5% H_2O_2 at pH 11.5 and soaking for 48h remove the most lignin content effectively. The amount of weight loss after H_2O_2 pre-treatment was due to lignin removal (Wyman 1996 and Dawson and Boopathy, 2008). The % of weight loss indicate that the removal of lignin from total amount of lignin (14.1% for Corn stover, 17.4% for sugarcane waste and 12.8% for Bambara groundnut chaff).

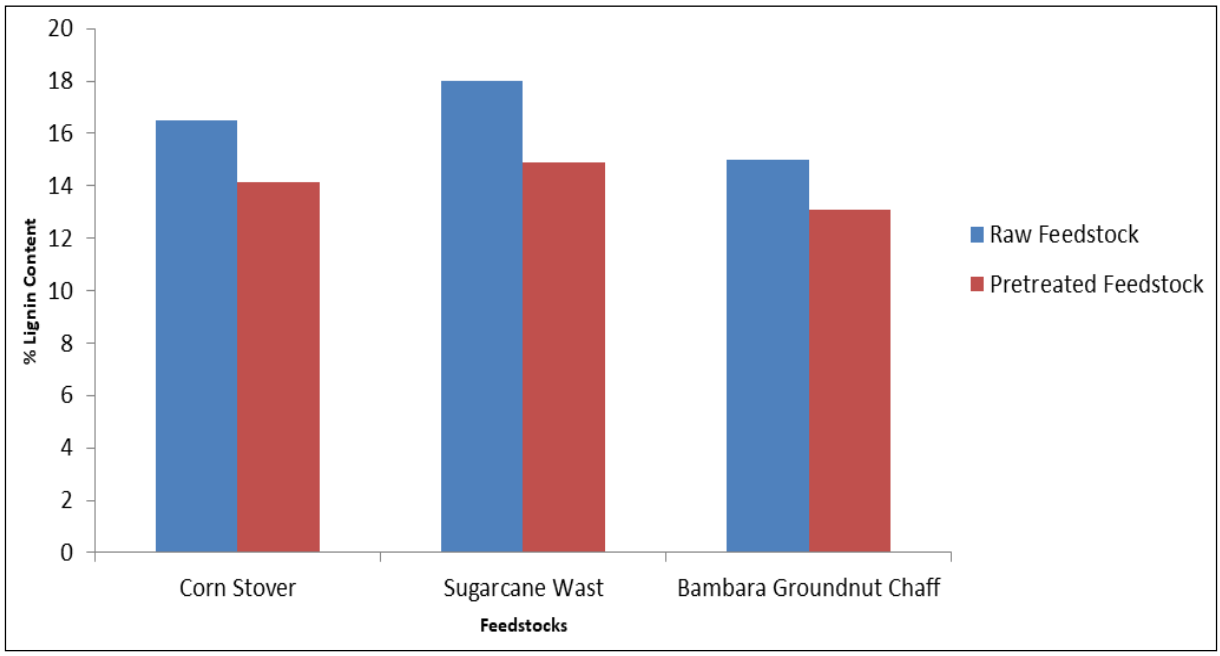

Fig 2: Effect of Hydrogen Peroxide Pretreatment on Delignification of the Feedstocks

Results on the Determination of Feedstock Mixing Ratio for Optimal Cellulose Yield after Pre-Treatment

The effect of feedstock (Corn Stover: Sugarcane waste: Bambara groundnut chaff) mixing ratio on the cellulose yield after pre-treatment was studied by varying the quantity of each feedstock as described in effect of pH. The Result obtained in the Fig. 3 showed that increased in sugarcane waste feedstock had highest influence in the overall cellulose yield of the mixture after pretreatment. This may be attributed to the high cellulose content of the feedstock as shown in Table 3. It could be observed in Fig. 3 that the highest cellulose yield was recorded in the feedstock mixing ratio of (1:3:1) that is 30g of Corn Stover, 90g of sugarcane waste and 30g of Bambara groundnut waste given total mass of 150g mixture, hence becomes the Optimal Mix Ratio of the feedstocks used in this work for Sucrose production.

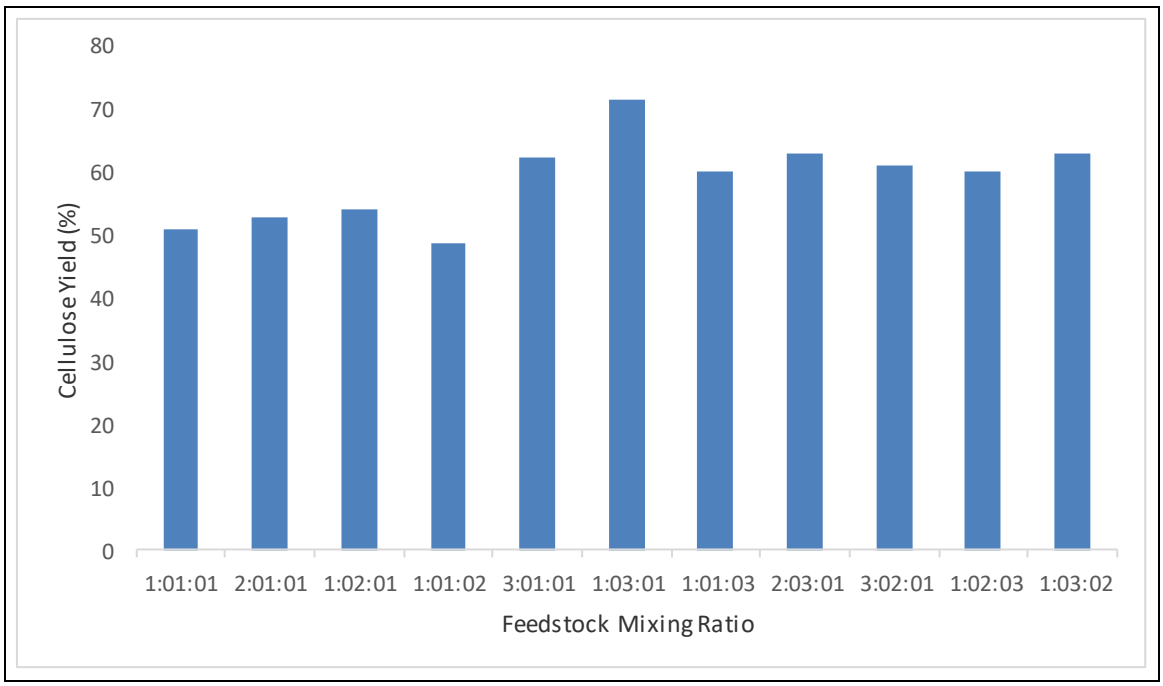

Fig 3: Results on the Determination of Feedstock Mixing Ratio for Optimal Sucrose Yield after Pre-treatment

Isolation of Aspergillus Niger

The growth of *Aspergillusniger* was monitored on soil at 30^{o}C. The spores initially observed as white turned to yellow which later become dense dark brown to carbon black mass. A sample of the black colony was sub-cultured ten times, which produced a fairly homogenous black colony.

Effect of Process Parameters on Sucrose Yield from Optimal Mix Ratio of (1:3:1) of Corn Stover, Sugarcane Waste and Bambara Groundnut Chaff, Cellulose by Enzymatic Hydrolysis

Effect of Temperature

Fig. 4. Depicts the effect of temperature on the yield of Sucrose from Corn Stover, Sugarcane waste and Bambara groundnut feedstocks optimally mixed in the ratio of (1:3:1). From the Fig., it could be observed that as temperature increases the yield of Sucrose increases. A maximum Sucrose s yield of 71.52% was obtained at temperature of 35ºC after 5days of enzyme hydrolysis and Sucrose yield decreased when the temperature was increased beyond 35ºC. The maximum temperature of 35ºC as observed might be due to the fact that enzyme activity andother chemical reaction in the cells were favoured at this temperature. The decline in yield witnessed beyond 35ºC could be that the enzyme was denatured at higher temperature.

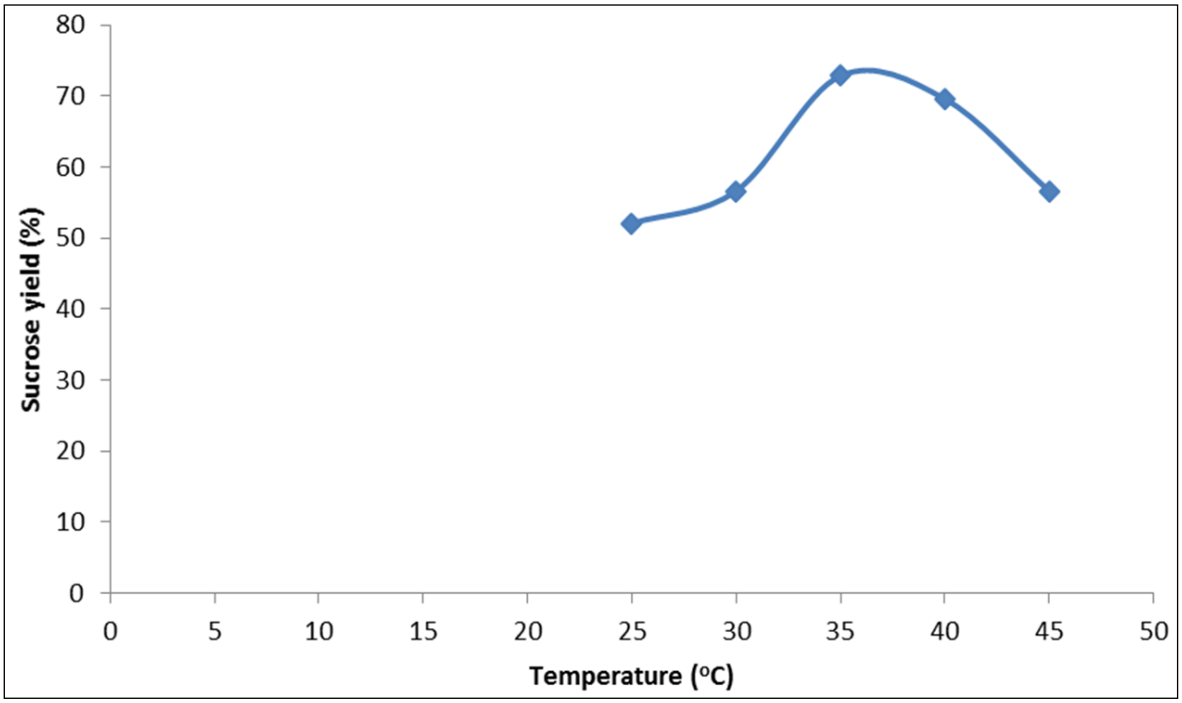

Fig 4: Effect of temperature on Sucrose yield by enzymatic hydrolysis. Reaction conditions: Time = 5days, pH = 5.5, Enzyme dosage = 8 g/mol.

Effect of Time on Sucrose Yield

Fig. 5 shows the effect of time on Sucrose yield from the mixed feedstock. From the Fig., it could be observed that Sucrose yield increases as time increased up to 5days of the hydrolysis and slightly declined. This may be due to consumption of cellulose in the bioreactor by the enzyme after 5days of hydrolysis. Similar trend was observed by Lisa *et al*., (2012) on enzymatic hydrolysis of rice straw.

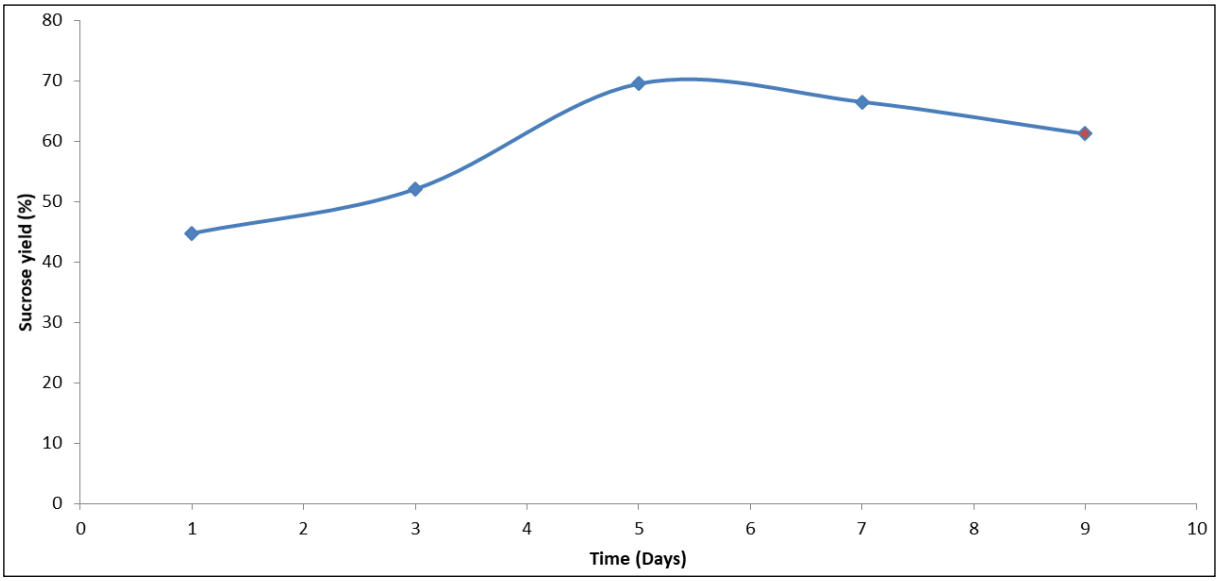

Fig 5: Effect of time on Sucrose yield. Reaction Conditions: Temperature = 35ºC, pH = 5.5, Enzyme dosage = 8 g/mol.

Effect of PH on Sucrose Yield

Results obtained in Fig. 6 showed the effect of pH on Sucrose yield from the mixed feedstock. The Result obtained showed that, as the pH increased from 1.5 to 5, the Sucrose yield increase to 71.2%. Further increase in pH beyond 5.5 resulted in decrease in the yield of Sucrose. The decrease in Sucrose yield may be due to the fact that enzymes are more active in mildly acidic medium (pH of 4.5-5.0 for *A. niger*cells and pH of 5.0-5.5 for yeast cells). The reported pH tolerance range for yeast is 3.5-6.5 while that of *A. niger*is 3.5-8.0.

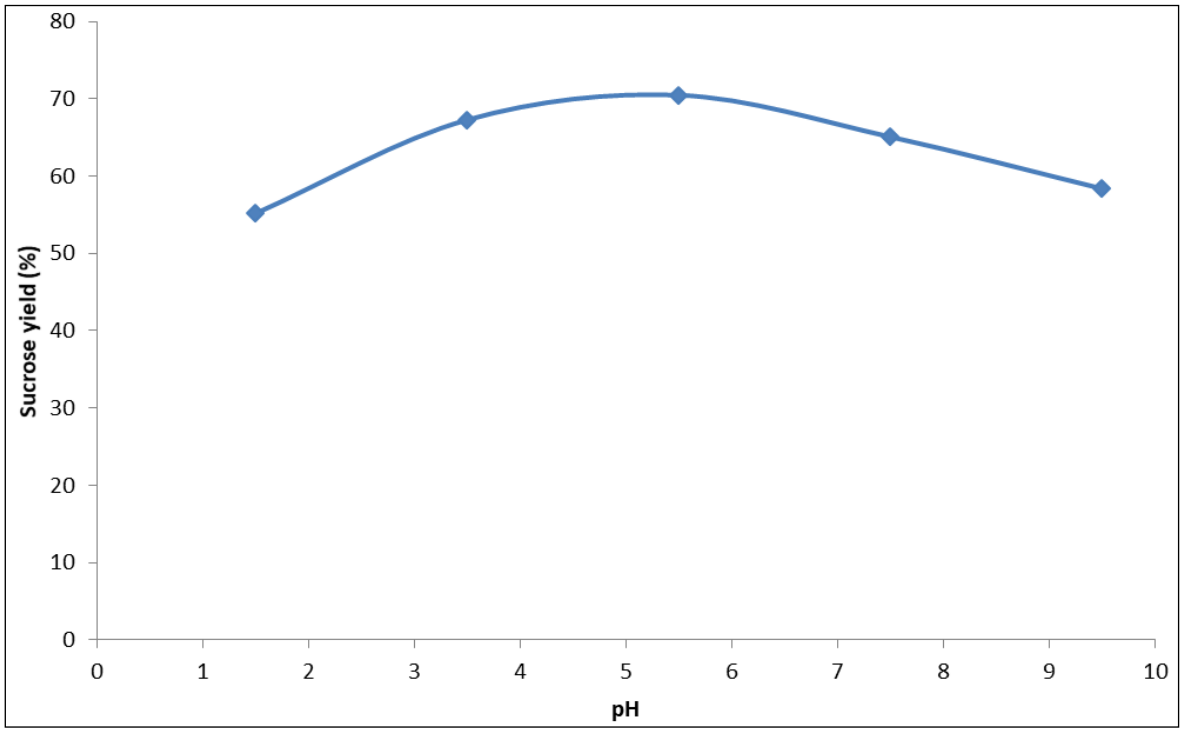

Fig 6: Effect of pH on Sucrose yield. Reaction conditions: Temperature = 35ºC, Time = 5days, Enzyme dosage = 8 g/mol.

Effect of Enzyme Dosage on Sucrose Yield

The effect of *Aspergillusniger* dosage on sucrose yield from the mixed feedstock cellulose was investigated and shown in Fig.7. The Result obtained in Fig.7 showed that as *A. niger* concentration increases from 2g/50ml to 8g/50ml, Sucrose yield increases from 50 to 69.5% for 5days of hydrolysis. Subsequent increase in *A. niger* concentration beyond 8g/50ml resulted in decrease of Sucrose yield. This may be due to the fact that as more cells were introduced and substrate concentration was not increased proportionally, was being used up by the cells for survival, hence resulting in low Sucrose yield.

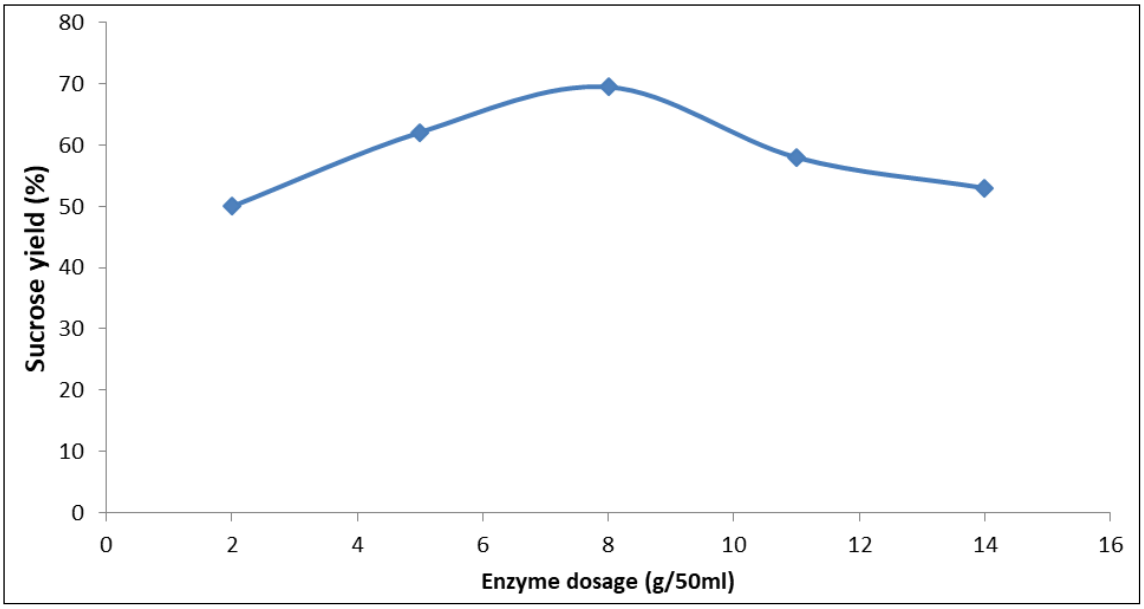

Fig 7: Effect of enzyme dosage on Sucrose yield. Reaction conditions: Temperature = 35ºC, Time = 5days, pH = 5.5.

Results of Chemical Properties of Sucrose Produced.

Table3 tabulates the properties of the feedstock used for the production of Sucrose. The waste feedstock used was examined and characterized to possess the chemical properties as reported in Table 8-12. It was observed that the Sucrose in its natural state has a Brownish in Colour. The density of the Sucrose syrup was determined by using Pyknometer (Density Bottle) and found the Density of Sucrose Syrup to be 1.490g/ml or 1,490kg/m^3. This shows that it will sink when mixed with water. Also, it has 1.490g/ml specific gravity.

The Flash Point of the Sucrose Syrup showed that it has a Flash Point temperature of 373.0^{0}C and the Pour Point temperature of 184.9 ^{0}C and Fire Point temperature of 350.2 ^{0}C.

in it.

Table 3: Results of Characterization of Chemical Properties of Sucrose Produced.

S/N	Stream: Sucrose Production From Feedstock	Unit	Result
1	Colour	-	Brownish
2	Density	g/ml	1.490
3	Specific gravity	g/ml	1.49
4	Flash Point	^{0}C	373.0
5	Pour Point	^{0}C	184.9
6	Fire Point	^{0}C	350.2
7	Calorific Value	j/g	4.182

Table 4: Experimental Results of Design Matrix of Enzyme Hydrolysis

Std	A: Temperature	B: Time	C: pH	D: Enzyme dosage	Yield of Sucrose by enzyme hydrolysis
	Deg.Cel	Days		g/50ml	%
1	30	3	1.5	5	45.4
2	40	3	1.5	5	55
3	30	7	1.5	5	43.4
4	40	7	1.5	5	52.3
5	30	3	2.5	5	50.7
6	40	3	2.5	5	63
7	30	7	2.5	5	44.8
8	40	7	2.5	5	48.8
9	30	3	1.5	11	38.9
10	40	3	1.5	11	46
11	30	7	1.5	11	49.8
12	40	7	1.5	11	49
13	30	3	2.5	11	47.1
14	40	3	2.5	11	51.1
15	30	7	2.5	11	54.6
16	40	7	2.5	11	52.1
17	25	5	2	8	46
18	45	5	2	8	58.1
19	35	1	2	8	52.1
20	35	9	2	8	51.1
21	35	5	1	8	40.3
22	35	5	3	8	45.6
23	35	5	2	2	55
24	35	5	2	14	51.8
25	35	5	2	8	69
26	35	5	5.5	8	71.41
27	35	5	2	8	70
28	35	5	2	8	69
29	35	5	2	8	68.9
30	35	5	2	8	70

Experimental Result of Design Matrix of Enzyme Hydrolysis

30 Experiments were carried out as reported in Table 4 of the Experimental Result of Design Matrix of Enzyme Hydrolysis.

Validation of Results

The Results in table 5 below shows the results of the model validation of optimum sucrose production by Enzymatic Hydrolysis of Cellulose.

Table 5: Experiment to Validate the Optimum Sucrose Production by Enzymatic Hydrolysis of Cellulose.

Experiment	Temperature ^{o}C A	Time (Days) B	pH C	Enzyme dosage (g/50ml)	Predicted yield (%)	Experimental Sucrose yield (%)
1	35	5	5.5	8	68.9	71.41

Conclusions

Conclusions

From the Results obtained from this study the following conclusions were drawn:

1. Corn Stover, Sugarcane waste and Bambara groundnut chaff have good quantity of hydrolysable cellulose
2. The optimal mix Ratio of the three feedstocks are; (1:3:1) for Corn Stover, Sugarcane waste and Bambara groundnut chaff gave cellulose yield of 89.02%
3. The optimum conditions for Sucrose yield of 71.41 by enzymatic hydrolysis are temperature, 35^{o}C, time, 5days, pH 5.5 and enzyme dosage, 8g/50ml.
4. Enzyme hydrolysis obeyed Michealis-Menten kinetic model.
5. Thermodynamic parameter shows that enzymatic hydrolysis of the mixed feedstocks is feasibile

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