Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

SINGLE CELL PROTEIN (SCP) PRODUCED FROM BIOCONVERSION OF PINEAPPLE PEELSUSING *Saccharomyces cerevisiae* ISOLATED FROM BURKUTU

[1]*Mohammed, S.S.D..[2]Auta, K.I,[3]Abdul-Rahman, A. A. and [1]Kadir, Y.A

[1]Department of Microbiology, Faculty of Science, Kaduna State University, Kaduna, Nigeria
[2]Department of Biological Sciences, Faculty of Science, Kaduna State University, Kaduna, Nigeria
[3]Department of Biological Sciences, Federal University, Lokoja, Nigeria
Email: mohammed.sambo@kasu.edu.ng

ABSTRACT

Most Agro-allied wastes scattered in the environment as pollutants, can be bioconverted to single cell protein.Single-Cell Protein (SCP) represents microbial cells (primary) grown in mass culture and harvested for use as protein sources in foods or animal feeds. The production of single cell protein (SCP) from pineapple peels using *Saccharomyces cerevisiae* isolated from burkutu was investigated. The yeast was isolated using pour plate technique on saboraud dextrose agar (SDA) medium and was identified using standard techniques. The single cell protein (SCP) produced wereSCP sample A (control), sample B (glucose + mineral + nitrogen source), sample C (mineral + nitrogen sources) in submerged fermentation (SF). Physicochemical,pre and post proximate analysis/ composition of the pineapple peel and SCP and microbial analysis of the single cell protein (SCP) were carried out. The yeast isolated was identified as *Saccharomyces cerevisiae.* Sample B gave the highest yield of 5.42% followed by sample C whichhad 4.60% while sample A (control) had the least yield of 4.50%.The physicochemical parameters showed varying values from the beginning of the fermentation to the end.The result of the proximate composition of pineapple peel before fermentation revealed moisture content of 4.80%, ash content of 4.72%, protein content of 4.30% , fat content of 4.07%, crude fibre content of 16.92% and carbohydrate content of 65.19%. The results of SCP samples showed that there were variations in the proximate compositions with sample B as the best. The SCP can serve as alternative to other protein souces.

Keywords: SCP,Burkutu, Fermentation, Proximate, Yield

1.0 INTRODUCTION

The continual population growth in developing countries has required an increase in animal and human food supply. The increased world demand for protein rich food to the search for the formulation of alternative protein sources to supplement conventional protein sources (Najafpur and Ghasem, 2007). Single cell protein or other related substances are basically proteins derived from organic matter using microbial organisms for the industrial production of SCPs various kind of substrates and microbes are used (Dube *et al.,* 2017).Single cell protein (SCP) is one of the important steps for this goal and is an alternative and innovative way to successfully solve the global food problem (Najafpur and Ghasem, 2007).

A lot of research was been done for reprocessing and reuse of different fruit waste for the conversion of valuable and nutritive products (Mahmood, 2012). Yeasts are probably the most widely accepted and used microorganisms for single cell protein production (Nasseri *et al.,* 2011). Yeast, in general has several advantages over bacteria and algae including better public acceptance; lower content of nucleic acid, easier harvesting because of their size and concentration; and growth on

***Corresponding Author**

How to cite this paper: Mohammed, S.S.D., Auta, K.I, Abdul-Rahman, A. A., & Kadir, Y.A (2018). Single cell protein (SCP) produced from bioconversion of pineapple peels using saccharomyces cerevisiae isolated from Burkutu. *Confluence Journal of Pure and Applied Sciences* (CJPAS), 1(2), 64-73.

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

substrate at low pH. Nasseri *et al.* (2011) reported that single cell protein (SCP) has a number of advantages over traditional source of protein with a number of advantages over traditional source of protein. Microorganisms grow rapidly and have high protein content that can be easily modified genetically to produce favorable traits. Microorganism can be cultivated on a large scale anywhere in the world independent of soil or climatic conditions (Nasseri *et al.* 2011). Agricultural waste like pineapple peels constitute a major nuisance in Nigeria because of their abundance when disposed carelessly, they constitute health and aesthetic problem. However, biotechnology has now provided effective means of conversion of these wastes into useful products (Iyayi and Aderolu, 2006).

Single cell protein or other related substances are basically proteins derived from organic matter using microbial organisms. For the industrial production of SCPs, various kind of substrates and microbes are used (**Anamika*et al.,* 2017).**Single cell protein refers to dead, dry microbial cells or total proteins extracted from pure microbial cell culture and is produced using a number of different microorganism including bacterium, fungus, and Algae (Anupama and Ravindra, 2006). The SCP can also be called biomass, bioprotein, or microbial protein (Singh, 2011). Single cell proteins are the dried cells of microorganisms, which are used as protein supplement in human foods or animal feeds. Microorganisms like algae, fungi, yeast and bacteria utilize inexpensive feedstock and wastes as sources of carbon and energy for growth to produce biomass (Nasseri *et al*., 2011). Besides high protein content (about 60 – 82% of dry cell weight), single cell protein also contains fats, carbohydrates, Nucleic acid, vitamin and mineral (Jamel *et al.,* 2008). Another advantage with single cell protein is that it is rich in certain essential amino acid like lysine, methionine which are limiting in most plant and animal foods. The protein can be used as additive added to the main diet instead of sources know very expensive such as soybean and fish (Gad *et al.,* 2010).

People in the third world and developing countries are suffering from menace of protein deficiency in their diets resulting in serious protein-energy malnutrition problems. The worldwide flood protein deficiency is becoming alarming day to day with the fast growing population of world; pressure is extent to the feed industry to produce enough animal feed to meet the region‟s Nutritional requirements. Microorganisms that are considered for food or feed which are been used includes algae, bacteria, yeasts, molds and higher fungi. The dried cells of these organisms are collectively referred to as single cell protein. This study aimedat producing single cell protein (SCP) from pineapple peels using *Saccharomyces cerevisiae*.

2.0 MATERIALS AND METHODS

2.1 Collection of Samples

The substrate (pineapple waste) which was collected from a fruit seller at Central Market Kaduna was transported to the Kaduna State University laboratory in a clean polythene bag.

2.2 Sample Preparation and Pre-Treatment

The pineapple peel was washed under running tap water and was dried for further treatment. The dried sample was pre-treated by grounding to a fine powder using a mortar. Fifty (50) ml of 10% (w/v) HCL was added to the waste (40gm) in a conical flask, the mixture/solution was placed in water bath at a 100°C for one hour. After that it was allowed to cool and was autoclaved at 121°C for 15 minutes. The sterile solution/broth prepared was used as carbon and nitrogen source for biomass production (Lenihan *et al.,* 2010).

2.3 Isolation of Yeast from Burkutu

The test organism, *Saccharomyces cerevisiae* was obtained from the Department of Microbiology, Kaduna State University (KASU). It was isolated from a fermented drink (burkutu) using pour plate technique and was preserved on potato dextrose agar (PDA) slant and refrigerated at 4°C (Casalone *et al.,* 2010).

2.4 Cultural and Microscopic Characterization Yeast Isolate from Burkutu

The yeast colonies on potato dextrose agar (PDA) plates were observed for pigmentation, shape and size. Microscopic observations were carried out on

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

slides stained with methylene blue and examined at 10x and 40x objectives (Casalone *et al.,* 2010).

2.5 Biochemical Identification of Yeast Isolate from Burkutu

2.5.1 Sugar Fermentation Test

Four (4) ml of the indicator (methylene blue stain) was transferred into five (5) test tubes grouped into three (3), (fifteen (15) test tubes with one control). Each sugar was transferred into each test tubes labeled with the same type of sugar with different syringes to avoid mix up (1ml of Lactose, Fructose, Glucose, Mannitol and Sucrose was transferred). Durham tubes were inserted into each test tube at an inverted position in the test tube containing different sugars and air was removed after it was autoclaved. Three (3) inoculum were prepared from the isolates and werelabeled isolate 1,2,3 (I_1, I_2, I_3), first inoculum was transferred into the first five test tubes containing the different sugars (Lactose, fructose, glucose, mannitol and sucrose), the second inoculum was transferred into the second five set of test tubes containing the different sugars (Lactose, fructose, glucose, mannitol and sucrose), the third inoculum was transferred into the five set of test tubes containing different sugars (Lactose, fructose, glucose, mannitol and sucrose). After that, all tubes were allowed for fermentation (Oyeleke and Manga, 2008).

2.6 Proximate Analysis of the Substrate

2.6.1 Determination of Percentage Moisture Content

Five (5) g of the pineapple peel and SCP samples were weighed into Petri dishes separately and placed in air draught oven at 100°C for 1 hour at different time. The Petri dishes were then weighed after cooling at different times. The process was repeated thrice until a constant weight was obtained. Loss in weight was calculated as the percentage moisture content and this was expressed by the following formula:

$$\% \text{ moisture} = \frac{\text{loss in weight due to dryness} \times 100}{\text{Weight of sample taken}} = \frac{W2 - W3 \times 100}{W2 - W1}$$

Where; W1 = weight of empty crucible, W2 = weight of crucible + sample before drying,
W_3 = weight of crucible + sample after attaining constant weight on drying (Moronkola *et al*., 2011)

2.6.2 Determination of Percentage Ash Content

This was carried out as described by Moronkola *et al.* (2011), where porcelain crucible with lid was ignited in a hot Bunsen burner flame and transferred into desiccator to cool and the crucible was weighed. Exactly 5g of the samples each were weighed into the crucible and gently placed in the muffle furnace set at 600°C for 4 hours. The crucible was placed in desiccator to cool. The ashed sample in the crucible was weighed after cooling without the lid and the process repeated thrice for the sample. The result was calculated using the following formula:

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where, W_1 = weight of empty crucible,
W_2 = weight of crucible + sample before ashing
W_3 = weight of crucible + sample after ashing

2.6.3 Determination of Percentage Crude Fat/Lipid

Two (2) grams of the samples each were transferred into a beaker and weighed as W, 10ml of water was added, and the solid was dispersed by agitating it. 10ml of concentrated hydrochloric acid was added and immersed in a boiling water bath until the solid particle dissolved and the mixture become brown in colour. This was allowed to cool and 10ml of alcohol added and agitated vigorously. A dried clean flask was weighed and recorded as W_2 and the ether layer was transferred into the flask and placed in a boiling water bath to evaporate the ether. The extraction was repeated by adding 50ml diethyl

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

ether in order to evaporate the ether living the fat behind. The fat and the flask was weighed and recorded as W_1, then the fat content was calculated as follows:

$$\% \text{ fat} = \frac{W2 - W1}{W} \times 100$$

Where, W = weight of the sample
W_1 = weight of dried flask
W_2 = weight of dried flask fat residue.

(Moronkola *et al.*, 2011).

2.6.4 Determination of Percentage Protein Content

Five (5) gram of dried finely samples each were weighed on ashless filter paper. The paper with sample was folded and dropped into the digestion flask. 20ml of sulphuric acid (H_2SO_4) and 4 pieces of granulated zinc were added and shaken, then heated gently inside a fume cupboard for 6 hours. The content in the flask was allowed to cool. The solution was diluted with distilled water and transferred into 800ml Kjehldah flask. 100ml of 40% NaOH was added and distilled. This was followed by titration against 0.05% of boric acid solution using methyl red as indicator. The protein content was estimated from the amount of nitrogen present in the sample.

$$\% \text{ nitrogen content (N,\%)} = \frac{0.014 \times M \times V \times 100 \times D.F}{\text{Weight of sample}}$$

Where, M=is the actual molarity of acid
V is the volume of acid used
D.F= is the volume ratio of solution

% protein content = Nitrogen content x conversion factor based on the sample (Moronkola *et al.*, 2011).

2.6.5 Determination of Total Carbohydrate Content

The Total carbohydrate content of the sample was obtained as described by Moronkola*et al*. (2011), where the results from fat, protein, moisture and ash content analyses were summed and the carbohydrate content was calculated as follows: 100% -% moisture + % protein + % fat + % ash (Moronkola*et al.*, 2011).

A. Inoculum Development of *Saccharomyces cerevisiae*

The yeast inoculum $10^{-2} - 10^{-3}$ cell/ml were grown in a medium and compared with MacFaland turbidity standard. The medium containing (g/l): (0.3%) yeast extract, 1% peptone, 2% glucose, 1.5% agar and was adjusted to pH 5.0. The medium was autoclaved at 121°C and for 15 minutes and was poured on petri dish and cooled, then streaked by 48hours old selected yeast strain from slant. After preparation of inoculum broth (g/l) (0.3% yeast, 1% peptome, 2% glucose) the medium was autoclaved was autoclaved at 121°Cand 15 Psi and poured in conical flask and cooled, then inoculated with 48hours old selected yeast strain from petri dish and incubated at 30°C for 24 hours in vigorous shaking condition (18rpm) (Guimaraes*et al.,* 2006).

B. Fermentation and Harvesting of Single Cell Protein

Submerged fermentation was carried out in an erlenmyer flask (conical flask) with three trial media as descried by Jamel*et al.* (2008).

Sample A

The first medium had the fruit hydrolysate medium (FHM) only and inoculum (1ml), waste (40gm) 10% HCL (50ml) was made up to 1litre with distilled water. pH was adjusted to 5.5 using drops of 1N NaOH (sodium hydroxide).

Sample B

The second medium designated supplemented fruit hydrolysate (GFH) had all the composition of SFH (mineral and nitrogen sources) and glucose (2gm), inoculum (1ml), minerals (3.7gm), waste (40gm) 10% HCL 50ml was made up to 1litre with distilled

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

water. pH was adjusted to 5.5 using drops of 1N NaoH (sodium hydroxide).

Sample C

The third designated supplemented fruit hydrolysate (SFH) had the following composition, inoculum 1ml, minerals 3.7g ($(NH_4)_2$ SO_4 (2gm), KH_2 PO_4 (1gm), $MgSO_{4.7}$ H_2O (0.5gm), Nacl (0.1gm), $Cacl_2$ (0.1gm), waste (40gm), 10% HCL (50ml), was made up to 1ltr with distilled water. pH was adjusted to 5.5 using drops of 1N NaOH (sodium hydroxide). Fermentation was carried out at room temperature under static condition followed by determination of biomass and other parameters after 24 hours interval for six days as described by Raju*et al.* (2014).

C. Microbial Analysis of Single Cell Protein

Bacteria growth rate in the fermentation media was studied by inoculating 1ml of the inoculum into freshly prepared PCA and PDA after serial dilution (Iyayi and Aderolu, 2004).

D. Preparation of Plate Count Agar

Plate count agar using an analytical weight balance 4.38g of PCA powder was weighed and dissolved in 250ml of distilled water completely and heat for 1 – 2 minutes and autoclaved at 121°C for 15 minutes.

2.6.7 Determination of Single Cell Protein Yield

This was determined based on the concentration of the organism in the culture at 24 hours‟ interval for a period of seven days. A 1:10 dilution was made with distilled water using ten (10ml) of the medium. Same procedure was carried out on a blank sample containing only the pre-treated sample which was used to blank the spectrophotometer and absorbance, transmittance, concentration measured at 640nm.The absorbance value was used to drive the cell density which represents the yield of the organism (SCP) (Al-Mhanna, 2012).

2.6.8 Proximate Analysis of Single Protein (SCP)

After fermentation biomass were separated from culture broth using What man filtration. Before taking the weight of the biomass, it was transferred into an aluminum disk and was oven dried at 105°C for one hour followed by cooling in desiccators to balance the temperature and weight. The biochemical constitutes of separated biomass (Dry) such percentage crude protein, total carbohydrate content, reducing sugar and mineral content were determined (AOAC, 2006*)*.

3.0 RESULTS

Table 1 shows the cultural and morphological characteristics of *Saccharomyces cerevisiae.* The yeast isolates had flat elevation and were creamy in appearance. Yeast colonies appeared creamy (pigmentation) on PDA with shape and budding for vegetative morphological characteristics . All the sugars were fermented by the yeast isolates except for isolate (I_1) which revealed a negative result for maltose (Table2). The results from proximate composition of pineapple peel before fermentation is summarized on Table 3. Finding indicate that pineapple peel sample had a moisture content of 4.80%, ash content of 4.72%, protein content of 4.30% and fat content of 4.07%, crude fibre content of 16.92% and carbohydrate content of 65.19%. The carbohydrate content was higher than the protein content. The result also showed that after fermentation and production of single cell protein, sample A with the (FHM) had % moisture content of 5.70, ash content of 4.78%, protein content of 4.50%, lipid content of 10.92%, fibre content of 17.24% and carbohydrate content of 56.86% (Table 3). Also, the result obtained from SCP sample B with the designated supplemented fruit hydrodrolysate (GFH) revealed that moisture content was 6.93%, ash content of 3.97%, protein content of 5.42%, lipid content of 12.22%, fibre content of 14.04%, and carbohydrate content of 57.42%. The result obtained from SCP sample C with the designated supplemented fruit hydrolysate (SFH) had %moisture content of 5.92, Ash content of 4.90%, protein content of 4.60%, lipid content of 11.03%, fibre content of 17.32%, and carbohydrate content of 56.23%.

The amount of protein produced from pineapple peel waste by *S. cerevisiae* showed that the highest yield was 5.42% (Sample B), followed by sample C with 4.60% while Sample A had the lowest yield of 4.50% . The total carbohydrate content produced from Sample A, Sample B and Sample C were 56.86%, 57.42%, 56.23% respectively, with Sample B having the highest yield of carbohydrate which is 57.42%. Pineapple fruit peel also contained variable ingredients such as carbohydrate, protein, fat and mineral which are useful in the growth of the yeast in the production of single protein (SCP)

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

(Table 3). The physiochemical constituent of pineapple peel substrate from 0.00hours to 144hours and spectrometric analysis is presented in tables 4 to 9 with significant variations within parameters and values. The result obtained showed the parameters of single cell protein (bioprotein) for fruit hydrolysate medium, glucose fruit hydrolysate medium and supplemented fruit hydrolysate medium. The microbial analysis of single cell protein (bioprotein) is presented in table 10.The result obtain revealed that there was no bacteria contamination of the SCP

Table 1: Cultural, Morphological and Microscopic Characteristics of *Saccharomyces cerevisiae*

Isolates	Colonial appearance			Vegetative Morphology		Microscopic Characteristics		Inference
	Pigmentation Form	Size		Shape	Budding	Background	Shape	
I_1	Creamy	Large	Smooth	Elongated	Positive	Light blue	Round blue colonies	*Saccharomyces cerevisae*
I_2	Creamy	Small	Smooth	Round	Positive			*Saccharomyces cerevisae*
I_3	Creamy	Large	Smooth	Flat	Positive			*Saccharomyces cerevisae*

Table 2.Sugar Fermentation ability of Different *Saccharomyces cerevisie* Isolated from Burkutu

Sugars	*Saccharomyces cerevisiae*		
	I_1	I_2	I_3
Lactose	A	AG	AG
Fructose	AG	A	AG
Glucose	AG	A	AG
Maltose	-	A	AG
Sucrose	AG	A	AG

KEY: A-acid. G- Gas. AG- Acid gas

Table 3: Proximate Composition of Pineapple Peel and SCP (Biomass)/ Bioprotein

Parameters (%) Peel	SCP/ Biomass Samples		
	A	B	C
Moisture Content 4.80	5.70	6.93	5.92
Ash Content 4.70	4.78	3.97	4.90
Protein Content 4.30	4.50	5.42	4.60
Lipid Content 4.07	10.92	12.22	11.03
Fibre Content 16.92	17.24	14.04	17.32
Carbohydrate 65.19	56.86	57.42	56.23

Key:
A – Fruit hudrolysate Medium (Control)
B – Glucose fruit hydrolysate medium. (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Table 4: Spectromery and Physiochemical Constituent of Pineapple Peel Substrate after 0.00hrs of Fermentation

Parameters	SCP Samples			Blank Samples
	A	B	C	
Transmittance(640nm)	5.5	6.6	7.7	48.5
Absorbsance (640nm)	1.025	1.181	1.128	0.313
Concentration (640)	1536	1186	1105	313
Initial Temperature	20	29.5	29.4	
Initial pH	5.5	5.4	5.0	
TTA	7.4	9.0	7.05	

Key: TTA-Total Titratable Acidity
A – Fruit hydrolysate Medium (control)
B – Glucose fruit hydrolysate medium (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

Parameters	SCP Samples			Blank Samples
	A	B	C	
Transmittance (640nm)	16.9	5.3	5.7	48.5
Absorbance (640 nm)	0.77	1.29	1.279	0.313
Concentration (640 nm)	782	1264	1283	313
Temperature	20	29.5	29.4	
pH	5.0	5.4	4.8	
TTA	7.4	9.0	7.05	

Key: TTA-Total Titratable Acidity
A – Fruit hydrolysate Medium (control)
B – Glucose fruit hydrolysate medium (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Table 6: Spectrometry and Physiochemical Constituents of Pineapple Peel Substrate after 72 hours of Fermentation

Parameters	SCP Samples			Blank Samples
	A	B	C	
Transmittance (640nm)	7.5	6.0	7.1	48.5
Absorbance (640 nm)	1.126	1.217	1.132	0.313
Concentration (640 nm)	1121	1.132	1.132	313
Temperature	20	29.5	29.4	
pH	5.4	5.5	5.3	
TTA	7.4	9.0	7.05	

Key: TTA-Total Titratable Acidity
A – Fruit hydrolysate Medium (control)
B – Glucose fruit hydrolysate medium (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Table 7: Spectrometry and Physiochemical Constituents of Pineapple Peel Substrate after 96 hours of Fermentation

Parameters	SCP Samples			Blank Samples
	A	B	C	
Transmittance (640nm)	12.3	6.8	9.0	48.5
Absorbance (640 nm)	0.911	1.162	1.045	0.313
Concentration (640 nm)	911	1165	1042	313
Temperature	20	29.5	29.4	
pH	5.4	5.3	5.0	
TTA	7.3	9.1	7.05	

Key: TTA-Total Titratable Acidity
A – Fruit hydrolysate Medium (control)
B – Glucose fruit hydrolysate medium (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Table 8: Spectrometry and Physiochemical Constituents of Pineapple Peel Substrate after 120 hours of Fermentation

Parameters	SCP Samples			Blank Samples
	A	B	C	
Transmittance (640nm)	7.7	4.6	4.4	48.5
Absorbance (640 nm)	1.110	1.334	1.351	0.313
Concentration (640 nm)	1110	1.351	1351	313
Temperature	20	29.5	29.4	
pH	5.4	5.5	5.2	
TTA	7.7	9.4	7.15	

Key: TTA-Total Titratable Acidity
A – Fruit hydrolysate Medium (control)
B – Glucose fruit hydrolysate medium (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Table .9: Spectromery and Physiochemical Constituents of Pineapple Peel Substrate after 144 hours of Fermentation

Parameters	SCP Sample			Blank Samples
	A	B	C	
Transmittance	9.5	5.3	5.8	48.5

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

(640nm)				
Absorbance (640 nm)	1.019	1.271	1.235	0.313
Concentration (640 nm)	1019	1.235	1235	313
Temperature	20	29.5	29.4	
pH	5.2	5.3	5.0	
TTA	7.7	9.4	7.15	

Key: TTA-Total Titratable Acidity
A – Fruit hydrolysate Medium (control)
B – Glucose fruit hydrolysate medium (Glucose + Mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

Table 10: Microbial Analysis of Single Cell Protein (Bioprotein)

Day	Single Cell Protein		
	A	B	C
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	-	-	-
6	-	-	-

Key:
= No bacteria contamination
+ = Presence of Bacteria contamination
A – Fruit hydrolysate Medium (Control)
B – Glucose fruit hydrolysate medium (Glucose + mineral + Nitrogen sources)
C – Supplemented fruit hydrolysate medium (Mineral + Nitrogen source)

4.0 DISCUSSION

The cultural, morphological, microscopic and biochemical characteristics of the yeast isolate confimed it as *S. cerevisiae.* According to Casalone*et al.* (2005), the colony and cellular morphologies of natural and industrial populations of *S. cerevisiae*strains vary in response to different environmental stimuli. Variants of smooth colonies exhibiting rough colonies are common in certain species of *Saccharomyces*. Like in *Candida albicans*, the colony morphology is known to be related to the cell type: smooth colonies contain only blastopores, while rough colonies consist of different proportions of true hyphae and pseudohyphae as reported by Novak *et al.* (2008). In fact, the formation of pseudohyphae influences the colony morphology, which then appears as a central body from which numerous branches extend (Casalone*et al.,* 2005). The *S. cerevisiae* strains exhibiting rough colonies and pseudohyphal morphology has been frequently associated with disturbances in the fermentation process, depending on the fermentation system and other operational conditions. However, little is known about their competitive status relative to typical strains of *S. cerevisiae* (smooth and creamy bright colonies and dispersed cells) (Casalone*et al.,* 2005). The changes in the physicochemical parameters during the fermentation could be attributed to the metabolic process of the fermenting organism (*S. cerevisiae*). This is similar to the report of Mensah and Twumasi (2016) who revealed that the biochemical analysis of the substrate revealed the following composition: pH of 5.5 and 4.7% (m/v) total soluble sugars during SCP production. The findings of the present study for proximate composition of pineapple peel fruit wastes corroborated with the studies of Bacha*et al*. (2011) and Mahnaaz*et al.* (2010). Sample B, which is the supplemented fruit hydrolysate medium (SFH) contained higher amount of carbohydrate, which might have favourably affected yeast biomass production. This type of composition to enhance biomass production has been reported by Lenihan*et al.* (2010). Though Sample A also contained high concentration of carbohydrate (56.86%) but supported less biomass production. This may be due to the less mineral content in sample A than B, hence, this resulted in lower growth of yeast biomass. Similar observation has also been reported earlier by Bach *et al.* (2011). Furthermore, Sample B had higher lipid content, especially limonene (antimicrobial) which makes hindrance in digestion process of microbes, thus depriving yeast cells from essential nutrients, resulting in supported less biomass production. Similar findings was reported by Talebnia (2008). The result clearly indicated that higher percentage of protein (5.42%) was found in yeast biomass when *S. cerevisiae* was grown on Glucose fruit hydrolysate (GFH) indicating the biomass yield can be increased when a carbon source like glucose is added to the medium. Similar observation had been reported by Yakoub and Umar

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

(2010) with *Penicillum expansion*. The low yield of protein (4.50%) obtained from fruit hydrolysate medium (FHM) could be as a result of limited concentration of nutrients, particularly carbon source required for microbial growth. This highlights the importance of supplementation to increase biomass yield. This is similar to the report of Mensah and Twumasi (2016) who revealed that .maximum yield and doubling time/hr of SCPs (3.01 kg/m^3, 1,108 hr) was observed for the 60% (v/v) pineapple substrate concentration. The 100% (v/v) substrate concentration produced the least SCP yield of 2.5 3 1022 kg/m3 in a study they conducted on the use of pineapple waste for single cell protein (SCP) production and the effect of substrate concentration on the yield.

5.0 CONCLUSION

In conclusion higher yield of single cell protein from pineapple peel using *S. cerevisiae* was possible in a submerged fermentation of the three substrates (Sample A, Sample B and Sample C). The degree of single cell protein production depends on the type of substrate used and also on media composition. The addition of glucose provided available carbon source for the organism thereby enhancing single cell protein production. The present finding revealed that pineapple peel is useful as potential source for product with higher protein content by utilizing various ingredients present in it. Therefore, fruit wastes should be exploited properly as a substrate for the production of cellular biomass of edible yeast instead of dumping them as waste. The bio converted wastes can be used as feed supplement with least expenditure of money.

RECOMMENDATIONS

1. Fruit wastes should be exploited properly as substrate for the production of cellular biomass instead of dumping them in the drains and water bodies, so that they can be used as animal feed supplement and if suitable, for human consumption. And by so doing, it will reduce environmental pollution.
2. Further research should be carried out on other wastes for the production of single cell protein.

REFERENCES

Al-Mhanna, N.M.M. (2012). Single Cell Protein (SCP) Production from Date Juice.Msc.Thesis, Der TechnischenFakultät der Universität Erlangen-NürnbergzurErlangung des Grades.pp 5-9.

Anamika.,Seema, M., Meenakshi, S., Manju, S. and Prahlad, D. (2017). A Critical Review on Single Cell Protein Production using Different Substrates.***International Journal of Development Research.7(11): 16682-16687.***

Anupama, and Ravrindra, P. (2006). Value added food. Single cell protein.*Biotechnology advances,* 18: 459 – 479.

Association of Official Analytical Chemists, AOAC. (2006). *The Official Methods of Analysis of AOAC International*, 18th Edition, Arlington U.S.A.

Bacha, U., Nasir, M., Khalique, A., Anjum, A. A. and Jabbar, M. A. (2011). Comparative Assessment of Various agro-industrial Wastes for S. cerevisiae Biomass Production and Its Quality Production as a Single Cell Protein, *Journal of Animal and Plant Sciences*, 21(4), 844 – 849.

Casalone, E., Barberio, C., Cappellini, L., and Polsinelli, M. (2005).Characterization of *Saccharomyces cerevisiae* natural populations for pseudohyphal growth and colony morphology.*Research in Microbiology*. 156:191 – 200.

Dube, P.,Anamika, M., Seema,M., Meenakshi , S., . andManju, S .(2017). A Critical Review on Single Cell Protein Production using Different Substrates. *International Journal of Development Research* (7): 11, 16682-16687.

Gad, A. S., Hasan, E. A., and Abd El Aziz. A. (2010).Utilization of oputinaficusIndica waste for production of *Phenerochaetechrysoporium*bioprotein.*Journal of American science*, 6(8): 455-500.

Iyayi, E. A. and Aderolu, Z.A (2006).Enraicement of the feeding value of some agro industrial by products for layan hens after their solid state fermentation with *Trichodemaviride, African Journal of Biotechnology*, 3(3): 182 – 185.

Vol. 1, No. 2, Nov. 2018
ISSN: 2616-1303 | **Web:***www.cjpas.fulokoja.edu.ng*

Jamel, P., Alam, M. Z. and Umi, N. (2008). Media Optionazation for Bio Proteins Production from chapter carbon source, *Journal of Engineering Science and Technology,* 3(2): 124 – 130.

Lenihan, P., Orozco A., Neill, E. C., Ahmed, M. N. M., Rooney, D. W. and Walker G. M. (2010). Dilute add Hydrolysis of Lignocellulosic Biomass. *Chemistry Engineering Journal,* 156 (2): 395 – 403.

Mahmood, K. Y., (2012). To determine protein content of Single Cell Protein by using various combinations of fruit wastes in the production of SCP using two standard food fungi *Aspergillusoryae and RhizopusOligospora.International Journal of Advanced Biotechnology and Research,* 3(1): 533 – 536.

Mahnaaz, K., Shaukat, S. K., Zafar, A. and Arshiya, T. (2010).Production of Single Cell Protein from S. cerevisiae by Utilizing Fruit Wastes, *NanobiotechnicaUniversale*, 1(2), 127 – 132.

Mensah, J.K.M. and Twumasi, P.(2016). Use of pineapple waste for single cell protein (SCP) production and the Effect of substrate concentration on the yield.*Journal of Food Processing Engineering.*DOI 10.1111/jfpe.12478.

Moronkola, B.A., Olawu, R.A. Tovide, O.O.andAyejuyo,O.O.(2011).Determination of proximate and mineral contents. *Science Review for Chemical Commuminication*.1 (1):1-6.

Najafpur, E and Ghasem D. (2007) Biotechnology advances. *Biochemical Engineering and Biotechnology Advances,* 3(1):332 – 341.

Nasseri, A. T., Rasoul, A. S, Morowvat, M. H., and Ghasemi.Y. (2011). Single cell protein: production and process. *American journal of food technology,* 6(2): 103 – 116.

Raju, P. and Chandak, A. M. (2014).Production of single cell protein from fruit waste by using *Saccharomyces cerevisiae*. *International Journal of Advanced Biotechnology and Research* 4(5): 770-776.

Singh, V.P. and N. Sachan, (2011). Vitamin B_{12}-a vital vitamin for human health: A review. *American Journal of Food Technology*, 6: 857-863.

Talebnia, F., Mohammad, P., Lundin, M. amd Mohammad, J. (2008). Optimization Study of Wastes Saccharification by Dilute- acid Hydrolysis. *Biosciences.* 3 (1): 108-112.

Ware, S. (1997). Single Cell Protein and other Food Recovery Technologies from Waste.**Municipal Environment Research laboratory Office of Research and Development U.S Environmental Protection Agency - Cincinnati, Ohio.USA.**

Yakoub, K.M. and Umar, D.M. (2010). Effects of various Agricultural Wastes and Pure Sugars in the Production of Single Cell Protein by *Penicilliumexpansum*. *World Applied Science Journal*. 8: 80-84.