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Full Length Research Paper

Manufacture of yeast using acid-hydrolyzed cassava and poultry manure extract

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Cassava is made up of starch as its major nutritive reserve. Starch which is one of the most important products synthesized by plants is consumed as food and can be used in industrial processes. This investigation seeks to explore the availability of cassava as a source of glucose as well as poultry manure as a source of nitrogen in the production of yeast. Cassava flour was hydrolyzed with 0.5% (v/v) concentrated H_2SO_4 as carbon source for the production of yeast. It was found that pH 6.5 gave optimum yeast growth. Increased concentrations of acid-hydrolyzed cassava and poultry manure extracts led to significant ($P < 0.05$) increase in yeast biomass after 36 h culture. The residual glucose concentration was also determined and was found to be significantly ($P < 0.05$) increased with increase in the concentration of poultry manure extract. Therefore, yeast can be produced using acid hydrolyzed cassava flour as carbon source with poultry manure extract as nitrogen source. The methods described in this work can be used in the development of a rapid method of producing glucose and simple sugars from cassava through acid hydrolysis and combining this with poultry manure for yeast production.

Key words: Yeast, poultry manure extract, acid-hydrolyzed cassava.

INTRODUCTION

Yeasts (*Saccharomyces cerevisae*) have been known to humans for thousands of years as they have been used in fermentation processes like in the production of alcoholic beverages and bread leavening (Broach and John, 1991). The industrial production and commercial use of yeast started at the end of the 19th century after their identification and isolation by Pasteur (Bekatorov et al., 2006). During commercial production, yeast is grown under carefully controlled conditions on a sugar containing media typically composed of beet and cane molasses. Under ideal growth conditions, a yeast cell reproduces every two to three hours (Bekatorov et al., 2006). Studies show that organic nitrogen sources, such as yeast extracts support rapid growth and high cell yields of microorganisms because they contain amino acids and peptide, water soluble vitamins and carbohydrates (Peppler, 1982). The basic carbon and energy source for yeast culture are sugars (Dubai and Muhammad, 2005). Starch cannot be used because yeast does not contain the appropriate enzymes to hydrolyze this substrate to fermentable sugars. Beet and cane molasses are commonly used as raw material because the sugars present in molasses, a mixture of sucrose, fructose and glucose, are readily fermentable. In addition to sugar, yeast also requires certain minerals, vitamins and salts for growth. The number of yeast cells increases about five to eight-fold during fermentation (Glen and Dilworth, 2002).

Cassava (*Manihot esculenta*), also known as *manioc*, *tapioca* or *yucca*, is one of the most important food crops in the humid tropics, being particularly suited to conditions of low nutrients availability and is able to survive drought (Burelli, 2003). The major harvested organ is the tuber, which is actually a swollen root. Cassava is a source of calories for both human and animal feeding (Tonukari, 2004). The nutrient reserve of cassava is made up of starch which is consumed as food and used in industrial processes (Tonukari, 2004); although, cassava leaves are sometimes consumed. The acid catalyzed hydrolysis of starch is a complex

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heterogenous reaction. It involves physical factors as well as hydrolytic chemical reaction. The molecular mechanism of acid catalyzed hydrolysis of starch involves cleavage of glucan bonds. This is mainly on the α(1,4) bonds of amylose and α(1,6) bonds of amylopectin to produce several thousands of glucose residues. The hydrolysis is therefore controlled by both the reaction conditions (which are acid concentration and temperature) and the physical state of starch (Oboh and Akindahunsi, 2003). The treatment of starch as a mixture of several glucans with concentrated H_2SO_4 showed a reaction rate, two orders of magnitude higher than that of untreated starch about the same magnitude. However, the starch when treated with a varying level of H_2SO_4 undergoes an abrupt change in the physical structure of the glycosidic bond linking. ∝-amylose and amylopectin glycosidic bonds are broken to produce glucose and oligosaccharide residues (Burelli, 2003). The major hydrolytic product of cassava starch (glucose) can serve as a suitable carbon source for the production of *S. cerevisae*. The production of yeast is an important step to the commercial use of the product in baking, brewing and other applications (Broach and John, 1991).

The millions of kilograms of nitrogen collected and disposed off each day in animal manure and municipal waste represent a valuable reservoir of nitrogen potentially available for conversion to protein for livestock and poultry feeds as well as other valuable products. Traditionally, this nitrogen has been applied to land, where some of it is recycled into plant protein. However, the so called waste materials are now coming under close scrutiny because of increases in demand for plant proteins for human food. As a result, new and old systems are now being considered for their potential, in converting animal and municipal wastes into acceptable animal products (Anthony, 1971; Kyoung et al., 2007).

Various works have been carried out on the utilization of poultry manure on various applications (Obeta et al., 2009; Kargi and Shuler, 2005; Orhan et al., 2009). However, the present experimental design involves the use of acid-hydrolyzed cassava as carbon source and poultry manure extract as nitrogen source for the production of yeast. The purpose of this research is to develop a method for producing glucose and simple sugars from cassava (a locally available raw material) through acid hydrolysis and combining this with poultry manure for yeast production. The significance of this work is to use locally abundant agricultural products, cassava as well as agricultural waste (poultry manure) for the production of an industrial raw material, yeast.

MATERIALS AND METHODS

Cassava and poultry manure

Cassava (*M. esculenta*) tubers were purchased from Abraka Market in Delta State, Nigeria. It was peeled and thoroughly washed (to reduce the cyanide content). It was then sliced into small pieces, dried under the sun (open), after which, it was ground to flour and passed through a sieve of 0.25 mm before it was stored at room temperature in a dry plastic container, ready for use.

Acid hydrolysis of cassava

To get the best hydrolysis of cassava flour, varying weights (5 - 25 g) of cassava flour used at constant acid volume was weighed into six (6) conical flasks. To each of the conical flask, was added 0.5 ml of 0.5% (v/v) H_2SO_4 acid. The conical flask was then made up to 100 ml with distilled water and shaken thoroughly to have an even mix. It was autoclaved at about 115°C for 20 min, cooled and filtered into different sterilized test tubes as hydrolyzed glucose (sample glucose) and stored in a cool dry place.

Glucose estimation

The sample glucose estimation was carried out to determine the optimum hydrolysis of cassava flour. This was done using glucose estimation kit (Randox Laboratories Ltd, Diamond Road, Crumlin, Co. Antrim United Kingdom, BT29 4QY). Five test tubes were labeled test tubes 1 - 5 with tube 1 serving as the control. To each of the test tubes, 100 µl of hydrolyzed glucose filtrate, 2.0 ml of distilled water and 2.0 ml glucose buffer was added. This was incubated for 5 min at room temperature and optical density (O.D) taken using the spectrophotometer at 500 nm to estimate the amount of glucose as well as the optimum hydrolysis of cassava flour (Barham and Trended, 1972).

Poultry manure extract

Poultry manure (chicken droppings) was gotten from one of the poultries in Abraka, Delta State, Nigeria. It was dried under the sun (open air) and mashed to fine particles using mortar and pestle. It was then passed through a sieve of 0.25 mm and then stored in a dry plastic container, ready for use. To get a pure filtrate (extract) from the collected sample of poultry manure, 10 g of poultry manure was weighed into different conical flasks (at desired number). To each of the conical flask was added 100 ml of water. It was then filtered to remove the debris before autoclaving for 30 min. After autoclaving, it was filtered again using filter paper into different test tubes and stored at room temperature in a cool dry place to be used as nitrogen source for yeast culture.

Yeast tablets

Yeast tablets were purchased from a pharmaceutical store in Abraka, Delta State, Nigeria.

Preparation of yeast culture (YPD media) for inoculation

To prepare an uncontaminated yeast culture which is used for inoculation of different reaction media for yeast production, 2 g peptone, 2 g D-glucose and 1 g yeast extract was weighed into a 250 ml autoclaved conical flask. The content was mixed with a little amount of distilled water and the solution was made up to 100 ml with distilled water. The content was autoclaved for 30 min; it was brought out, cocked with cotton wool to make it air tight and then autoclaved again for another 30 min. After which, it was brought out and allowed to cool at room temperature. After cooling, 100 µl of 20% (w/v) antibiotics (ampiclox) was added to the solution to

Table 1. Glucose estimation after acid-hydrolysis of cassava.

Acid-hydrolyzed cassava	5%	10%	15%	20%	25%
O.D (500 nm)	1.757	1.723	1.707	1.785	1.268
Glucose concentration (mmol/L)	9.800	9.611	9.521	9.956	7.072
Amount of glucose (g)/100 ml	1.764	1.730	1.714	1.792	1.273

prevent bacteria growth before adding two tablets of yeast. Its content was thoroughly shaken to allow the tablet dissolve and the culture was incubated for 6 - 12 h before using the culture for inoculation of other substrate for yeast culture.

Yeast culture with varying poultry manure extract

To determine the yeast biomass using acid hydrolyzed cassava as carbon source and poultry manure as nitrogen source, 20 ml of the 20% acid-hydrolyzed cassava was measured into six (6) conical flasks having the glucose control flask; the poultry manure extract control flask containing 10 ml of poultry manure extract and four other flasks containing 2.5, 5.0, 7.5 and 10.0 ml of poultry manure extract, respectively. To the poultry manure extract control flask, there was no addition of 20 ml acid hydrolyzed cassava and no poultry manure extract was added to the glucose control flask. The pH in the conical flasks was adjusted to 6.5. This was done using the pH meter and NaOH solution (1.0 M) as alkaline medium. The total volume in each conical flask was made up to 100 ml with distilled H_2O. The flasks were then autoclaved for 30 min, allowed to cool, corked with cotton wool and re-autoclaved for another 30 min. After autoclaving the second time, it was allowed to cool and 100 µl of 20% (w/v) antibiotics (ampiclox) was added to each flask to prevent bacteria growth. 2 ml of the incubated yeast culture was then used to inoculate each of the conical flasks. The flask was thoroughly shaken and allowed to grow for 36 h. After the growth period, the OD was taken at 600 nm to determine the yeast biomass.

Yeast culture with varying acid-hydrolyzed cassava

To determine the yeast biomass using varying amount of hydrolyzed cassava as carbon source with poultry manure extract as nitrogen source, a varied amount of the 20% acid-hydrolyzed cassava was added from 2.5 - 20 ml into different conical flasks (flasks 2 - 9). To flask one, there was no addition, serving as control. 5% of poultry manure extract was then added to the different conical flasks. After these additions, subsequent procedures following the yeast determination is as previously described. In estimating the glucose after yeast culture using varied acid-hydrolyzed cassava, nine test tubes were used and labeled test tubes 1 - 9. All other procedures followed procedures previously described above. After the yeast biomass has been determined, the pH readings were also determined as previously described.

Yeast culture with varying pH

To determine the yeast biomass with varying pH using acid hydrolyzed cassava as carbon source and poultry manure extracts as nitrogen source, 20 ml of the 20% acid-hydrolyzed cassava was measured into six (6) conical flasks followed by the addition of 5 ml of poultry manure extract to the conical flasks. The pH of contents of the conical flasks labeled 2 - 6 was adjusted to 2.5, 3.5, 4.5, 5.5, and 6.5, respectively, with the exception of conical flask 1, which served as the control. This was done using the pH meter and NaOH (1.0 M) solution as alkaline medium. The total volume in each conical flask was made up to 100 ml with distilled H_2O after adjusting the pH. It was then autoclaved for 30 min, allowed to cool, corked with cotton wool and re-autoclaved for another 30 min. After autoclaving the second time, it was allowed to cool and 100 µl of 20% (w/v) antibiotics (ampiclox) was added to each flask to prevent bacteria growth. 2 ml of the incubated yeast culture was used to inoculate each of the conical flasks. The flask was shaken very well and allowed to grow for 36 h. After the growth period, the optical density (OD) was taken at 600 nm to determine the yeast biomass.

RESULTS

Acid hydrolysis of cassava flour

Acid hydrolysis of the cassava flour was carried out to determine the best hydrolysis of cassava flour varying the weights of cassava flour from 5 - 25 g at constant acid volume. At the end of the hydrolysis, the hydrolyzed glucose (sample glucose) was filtered into different sterilized test tubes and stored in a cool dry place. Glucose estimation of the varied hydrolyzed cassava was carried out as well as standard glucose estimation in comparison. This was to test for the optimal hydrolysis of cassava. This sample glucose estimation was carried out using the glucose kit and the result shows that 20% of the cassava flour gave the optimum hydrolysis as shown in Table 1. This gave the highest amount of glucose on hydrolysis which was significant at 5% level using F-test for statistical analysis. Thus, subsequent analysis for yeast production was carried out using 20% cassava flour for acid hydrolysis and the glucose produced was used for yeast production.

Yeast biomass estimation with varying poultry manure extract

The yeast biomass estimation analysis was aimed at determining the amount of yeast as well as determining the amount of residual glucose and the pH level (whether acidic or alkaline) after the yeast culture. This was done using the acid-hydrolyzed cassava (glucose) as carbon source and the poultry manure extract as nitrogen source. The results obtained using poultry manure extract is shown in Table 2. Yeast grows very well in the

Table 2. Yeast biomass estimation after 36 h culture using acid-hydrolyzed cassava (glucose) as carbon source and varying poultry manure extract as nitrogen source.

Acid-hydrolyzed cassava (%, v/v)	Poultry manure extract (%, v/v)	Yeast biomass ($OD_{600\ nm}$)**	Residual glucose (mmol/L)**	pH after yeast culture
20	0	0.507 ± 0.002	5.438 ± 0.002	4.39
20	2.5	0.550 ± 0.004	3.581 ± 0.002	4.45
20	5.0	0.568 ± 0.001	1.774 ± 0.001	4.44
20	7.5	0.629 ± 0.002	2.806 ± 0.002	4.46
20	10.0	0.677 ± 0.003	1.841 ± 0.002	4.48
0	10	0.306 ± 0.002	0.011 ± 0.000	4.94
	YPD	0.992 ± 0.002	7.351 ± 0.045	4.79

**Values are mean ± standard deviation of triplicate experiments. YPD = Yeast peptone dextrose culture medium containing 2% glucose.

presence of carbon and nitrogen. From Table 2, it is observed that, under the normal yeast culture (YPD), the yeast grew optimally compared to when another carbon source (acid-hydrolyzed cassava filtrate - glucose) and nitrogen source (poultry manure extracts) was used.

Using the constant percentage of acid-hydrolyzed cassava filtrate - glucose as carbon source together with varied percentage of poultry manure extract as nitrogen source, increased yeast biomass was observed as the percentage of the poultry manure extract increases which was significant at 5% level (Table 2). This indicates that, yeast grows very well in the presence of high amount of nitrogen and carbon. Table 2 also depicts glucose filtrate (acid-hydrolyzed cassava) control and poultry manure extract control. It was observed from the table that, in the presence of high amount of glucose filtrate (acid-hydrolyzed cassava) and no amount of poultry manure extract (poultry manure extract control), there was higher amount of yeast biomass compared to biomass in the presence of high amount of poultry manure extract and no amount of glucose filtrate (glucose filtrate control) at $P < 0.05$.

After the growth of the yeast at the specified incubation period, the residual glucose as well as the pH of the media after growth was measured. From Table 2, it was observed that, with increase in yeast biomass, there was significant decrease in the residual glucose concentration, which indicates that, much of the glucose have been used during the yeast growing process. It was also observered that the pH was acidic after yeast culture. Yeast grows optimally at pH 6.5. The reduced pH observed indicates that, after the optimal growth of yeast, the media in which the growth occurred became more acidic, because of the production of organic acids like lactic acid and malic acid.

Yeast biomass estimation with varying acid-hydrolyzed cassava

The yeast biomass estimation with varied acid-hydrolyzed cassava (glucose) was aimed at determining the yeast growth using various percentage of acid-hydrolyzed cassava (glucose). The amount of residual glucose and the pH after the yeast culture was also determined. The results obtained using poultry manure extract as nitrogen source is shown in Table 3. From the table, it was observed that, as the percentage of acid-hydrolyzed cassava (glucose) increases from 0 - 20%, there was also significant ($P < 0.05$) increase in the yeast biomass which indicates that, yeast biomass is dependent on carbon source in the presence of nitrogen (poultry manure extract).

After the growth of the yeast at the specified incubation period, the residual glucose concentration as well as the pH of the media after culture was measured. From Table 3, it was observed that, there was lesser yeast biomass, with high concentration of residual glucose. This indicates that, the lesser the yeast biomass, the more the residual glucose after yeast culture.

Also measured was the pH after yeast culture, which was observed to be acidic (reduced pH). The low pH observed indicates that, after the optimal growth of yeast, the media in which the growth occurred becomes more acidic because of the production of organic acids, like lactic and malic acid, as yeast grows optimally at pH 6.5 (Table 3).

Yeast biomass estimation with varying pH

The yeast biomass estimation with varying pH was aimed at determining the pH at which optimal yeast growth is observed. This experiment is necessary because, after acid hydrolysis, the medium became very acidic (about pH 1.3); thus, varying the pH helps to ascertain the minimum amount of NaOH needed to adjust the pH. The amount of residual glucose and the pH level (whether acidic or alkaline) after the yeast biomass was also determined. The results obtained using poultry manure extract as nitrogen source is shown in Table 4.

Table 3. Yeast biomass estimation after 36 h culture with varying amount of acid-hydrolyzed cassava (glucose) as carbon source and poultry manure extract as nitrogen source.

Acid-hydrolyzed cassava (%, v/v)	Poultry manure extract (%, v/v)	Yeast biomass ($O.D_{600\ nm}$)**	Residual glucose (mmol/L)**	pH after yeast growth
0	5	0.383 ± 0.008	1.902 ± 0.004	5.17
2.5	5	0.486 ± 0.008	2.214 ± 0.002	5.88
5.0	5	0.761 ± 0.008	2.194 ± 0.001	5.61
7.5	5	0.945 ± 0.013	2.181 ± 0.001	5.03
10.0	5	0.979 ± 0.008	2.298 ± 0.001	4.98
12.5	5	0.995 ± 0.019	2.479 ± 0.004	4.95
15.0	5	1.109 ± 0.010	3.561 ± 0.000	4.71
17.5	5	1.135 ± 0.005	3.583 ± 0.017	4.67
20.0	5	1.192 ± 0.003	3.587 ± 0.001	4.4

**Values are mean ± standard deviation of triplicate experiments.

Table 4. Yeast biomass estimation after 36 h culture with varying pH using acid-hydrolyzed cassava (glucose) as carbon source and poultry manure extract as nitrogen source

Acid-hydrolyzed cassava (%, v/v)	Poultry manure extract (%, v/v)	pH variation	Yeast biomass ($O.D_{600\ nm}$)**	Residual glucose (mmoles/L)**	pH after yeast growth
20	5	1.47***	0.220 ± 0.003	11.557 ± 0.011	2.35
20	5	2.5	0.269 ± 0.002	10.994 ± 0.016	3.36
20	5	3.5	0.454 ± 0.000	10.904 ± 0.004	3.96
20	5	4.5	0.456 ± 0.001	9.851 ± 0.002	4.78
20	5	5.5	0.743 ± 0.002	5.254± 0.006	5.24
20	5	6.5	0.796 ± 0.002	5.126 ± 0.008	5.37

**Values are mean ± standard deviation of triplicate experiments; ***pH after acid hydrolysis and before adjusting with NaOH (1 M).

Yeast grows best (optimally) at pH 6.5. From Table 4, the pH of the yeast media was adjusted to varying pH range, from pH 2.5 - 6.5 using 1 M sodium hydroxide (NaOH) solution as the alkaline medium while the acid-hydrolyzed cassava (glucose) was used as the acidic medium as well as carbon source; the poultry manure extract was, however, used as the nitrogen source. The pH of the medium before adjusting with 1 M NaOH (serving as the control for the analysis) was 1.47 for poultry manure extract.

Using constant percentage of acid-hydrolyzed cassava filtrate - glucose as carbon source and constant percentage of poultry manure extract as nitrogen source, high yeast biomass was observed as the pH variation increases from pH 2.5 - 6.5 and pH 6.5 gave the best (optimum) yeast growth (Table 4).

After the growth of the yeast at the specified incubation period, the residual glucose concentration as well as the pH of the media after growth was measured. From Table 4, it was observed that, as the pH increases, the residual glucose concentration after yeast growth decreases, which indicates that, as the pH variation increases from 2.5 - 6.5, there was high yeast biomass which resulted in low residual glucose concentration due to the high utilization of the carbon content in the acid-hydrolyzed cassava (glucose filtrate). This was significant at $P < 0.05$ using F-test for statistical analysis.

The results showed that the pH after yeast culture was acidic. However, it was also observed that, at other adjusted values of pH ranging from 2.5 - 4.5 with the controls inclusive, the pH values after the yeast culture was higher than the adjusted values, which indicates that, yeast does not grow very well in a highly acidic medium. Fair yeast growth was observed for adjusted pH 5.5, as the pH value after the yeast culture was seen to be reduced (acidic), but not as good as pH 6.5 (Table 4).

DISCUSSION

More than two-third of the total production of cassava is used as food by humans, with lesser amounts being used for animal feeds and industrial purposes (Nwokoro et al., 2002). Starch is one of the most important plant product

to man. Cassava starch, which is very bland in flavour, is used in processed baby foods as a filler material, and bonding agent in confectionary and biscuit industries (Tonukari, 2004).

Various industries have exploited the use of cassava in the production of many items such as textiles, cosmetics, glue and adhesive, pharmaceutical and cement (Tonukari, 2004). This experimental design seeks to explore the use of cassava flour as a source of glucose and poultry manure as source of nitrogen in the production of yeast. The results of the present study, shows that, acid hydrolyzed cassava flour (glucose) can serve potentially as a cheap carbon source for the production of yeast. This is due to the composition of starch in cassava and also the relative high availability of cassava (Ihekonronye and Ngoddy, 1985; Alais and Linden, 1999; Magnolia et al., 2006). Acid hydrolysis of cassava flour was used because of the advantages it has over saccharification by enzymes. The processes involved in acid hydrolysis of cassava flour is fast, cheap, high yielding and not affected by contamination (Ipsita and Munishwar, 2003).

The results obtained showed that, the hydrolysis of cassava flour gave a high yield of glucose which serves as good and cheap carbon source for yeast production. This is in agreement with the findings of Oboh and Akindahunsi (2003), who observed that, the hydrolytic product of cassava starch - glucose, serves as a suitable substrate in providing carbon source for the growth of yeast (*S. cerevisiae*). It also confirms Dubai and Muhammad (2005) observation that the basic carbon and energy source for yeast culture are sugars.

This research also shows that yeast culture can be enhanced with the use of poultry manure which serves as an alternative to peptone. Peptone is commonly used as nitrogen source for the growth of yeast. Poultry manure as a way of recycling environmental waste has been seen to be efficient as peptone, because of their similar level of yeast growth, and it can also be considered as a better and preferred source of nitrogen because of its abundant availability and the presence of mineral salts like phosphorus, potassium, calcium and magnesium which can as well aid in the growth and development of yeast (Albers et al., 1996; Yao et al., 2006).

The optimal growth of yeast as shown by studies is best in the presence of carbon and nitrogen sources; hence, glucose stands as an important carbon source for the growth of yeast with a dual role in biosynthesis, and energy generation and for microbial fermentation processes (Stanbury et al., 1995; Dubai and Muhammad, 2005) which was also confirmed in this experimental design. Poultry manure was used as nitrogen source for the production of yeast and CO_2 as by-products by micro-organisms as a result of the fermentation of sugar (Table 2).

In the course of the research, yeast growth was determined at varied pH values of 2.5 - 6.5 using poultry manure extract as nitrogen source and acid-hydrolyzed cassava as carbon source. The results showed that, yeast grows closer to neutral pH (Table 4). At pH 5.5 – 6.5, there was a sharp increase in yeast growth. This result is in agreement with the findings of Glen and Dilworth (2002), who studying the effect of nitrogen and carbon sources, showed that, the growth of the yeast reached a peak at a pH of about 7 (neutral pH) and was not able to grow when the pH of the medium was lower than 4.

Yeast biomass was also determined at varied values of the acid-hydrolyzed cassava using poultry manure extract as nitrogen source. The results showed that, yeast biomass increases with increasing amount of acid-hydrolyzed cassava as carbon source. Thus, confirming Dubai and Muhammad (2005), who found that, the basic carbon and energy source for yeast culture are sugars.

Conclusion

The methods described in this work can be used in the development of a rapid method for producing glucose and simple sugars from cassava through acid hydrolysis and combining this with poultry manure for yeast production. This research has taken the advantage of cassava flour in its rich content of starch to assess its ability to serve as a carbon source for the production of yeast using poultry manure extract as an alternative nitrogen source to peptone because of its availability. Yeast is currently imported into Nigeria for various uses. Local industries should take advantage of the results presented here to start yeast processing plants using readily available materials- cassava and poultry manure. These can yield an incredible savings in operation cost. This research can be extended using laboratory and pilot fermentors to optimize the various parameters for yeast production using these readily available local raw materials.

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