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Studies of the Effect of pH on the Fermentation of Cassava (*Manihot Esculenta*) Tubers

Iyasele, J. U. and Onyenue, D. E.
Department of Industrial Chemistry, University of Benin, Benin City, Edo State Nigeria.

Abstract
The effect of the difference in the acidity or alkalinity on fermentation of cassava tubers has been studied. The study was carried out by monitoring the rate of fermentation of the cassava samples at pH 5, 7, 9, and 11, and assessing the organoleptic properties and the physico-chemical properties of the final processed fufu samples from the fermented tubers. Cassava tubers was peeled, washed, chopped into bits and retted at different pH of 5, 7, 9 and 11 and were labeled as sample A. B, C and D respectively. The rate of fermentation was monitored by measuring the volume of gas evolved. After 45 hours of fermentation, it was observed that the rate of fermentation increased with increase in pH and this led to significant reduction in the smell Results obtained for proximate analysis of the samples show that moisture, carbohydrate, ash, ether extract, crude protein and crude fibre contents were of the range; 68.67-72.00, 21.19-23.94, 0.33, 0.36-0.45, 0.53-0.7, and 5.5-6.00% for samples A, B, C, and D respectively, inferring that pH does not significantly affect the overall physico-chemical properties of the processed fufu samples. Summarily, pH only affects the rate of fermentation of cassava, the smell and not the rest organoleptic and physico-chemical properties of the processed fufu samples.
Keywords: Cassava tuber, Fermentation, Fufu, pH

Introduction
Fermentation is a chemical change in food brought about by enzymes from living microorganisms. It is a food processing technique practiced by man for centuries in various part of the world especially Africa [1]. Fermented foods are prepared from plant and animal materials by processes in which microorganisms play important role in modifying the substrate physically, nutritionally and sensorily [2]. More than 80% of the inhabitants of Nigeria consume various fermented foods and beverages, which include: for staple - gari, fufu (akpu), elubo, abacha, akara-akpu, ogi (akamu), soy ogi, agidi tuwo, fura; for beverages – mmanya-ngwo (raffia palm wine), mmanya - nkwo(oil palm wine), ogogoro (distilled palm wine), pito, burukutu; milk products - gindiri (fermented milk), warakasi (local cheese) , for condiments- dawadawa, ugba , ogiri ,and eketeke [1].
Cassava (Manihot esculenta Crantz) is the staple food of more than 500 million people [3], and is a typical crop in developing countries. Cassava roots are potentially toxic due to the presence of cyanogenic glycosides especially linamarin [4]. Physiological deterioration occurs in cassava roots 2-5 days after harvesting followed by microbial deterioration 3-5 days later [5].
Fermentation of cassava entails steeping roots in water for 3 to 4 days. During the consequent fermentation, roots are softened. Disintegration of the tissue structure results in contact of linamarin with linamarase which is located in the cell walls [6].and subsequent hydrolysis to glucose and cyanohydrins, which easily break down to ketone and HCN [7]. Fufu, is a variant of fermented cassava product consumed as cooked dough at homes and eateries with various soups across West African countries where they are identified with different tribal or ethnic names [8]. It is produced from already fermented cassava by reconstituting it in water and stirring in boiling water to form dough and eaten with flavoured sauces. One potential problem in processed fufu is the flavour of the product, which may be undesirable to many people. The fermentation process is initiated as a result of chance inoculation of microorganisms from the environment. The presence of unspecified microorganisms complicates the control of the fermentation process and lead to the production of objectionable odours. Such problems have led to the development of several other processing techniques suitable for odourless fufu. [9, 10]. Most microorganisms are able to survive only in certain environment of pH (acidity or alkalinity) of a medium. It has also been suggested at certain local parlance undocumented that the faster the rate of fermentation of cassava the lesser the objectionable odour of the fufu produced from it. Fufu is considered by consumers to be of good quality when it has a smooth texture, a characteristic sour aroma and is creamy-white, grey or yellow in color as cited by. [11].

Correspondence E-mail: juiyasele@yahoo.com

This work is aimed at monitoring the effect of pH on the rate of fermentation of cassava so as to be able to optimize the length of time for the production of the popular 'Satana' food widely consumed in Nigeria while ascertaining the organoleptic properties and the physico-chemical properties of fufu.

Materials

The materials used for the studies are Jenway 3020pH meter, Rotary Evaporator RE-52C, Muffle Furnace (Model SXL-1008), Drying Oven (DHG-9023A) and Fume Hood (FH 1800). Copper sulphate, Sodium sulphate, Concentrated sulphuric acid, Boric acid, Sodium hydroxide, Potassium hydroxide, Phosphoric acid, Methyl red and Diethyl ether. All reagents used are of BDH and Poole England and are of analytical grade. TMS 30572 cassava cultivar was harvested from Crop Science Departmental farm, Faculty of Agriculture, University of Benin, Nigeria

Methods

Fufu production: The method of wet fufu mash production by Oyewole, [12] was used to produce wet fufu mash in the laboratory. The tubers after harvest were peeled, chopped into bits of about 1.5-2 cm and washed with tap water. 200g each, of the peeled chopped cassava tubers, were retted in 2-litres of tap water each of pH 5, 7, 9 and 11 respectively and labeled A, B, C, and D respectively in an air tight transparent plastic containers with screw lid at ambient temperature and the time taken for all the chopped cassava sample to rise to the top of the retting media was monitored. After 45 hours of retting, the chopped tubers were washed, mashed in clean water and sieved to remove the fibers and the vascular bundles. The mixture was allowed to settle and excess water decanted. The wet fufu mash was transferred into a clean jute bag and the remaining water pressed out. The fufu samples (100g each) were prepared by stirring gently in 50 ml of boiling water. The paste was stirred continuously for about 6-7 minutes over low heat, until a dough-like consistency was obtained.

Fermentation rate analysis: The rate of fermentation of the cassava samples A, B, C, and D were monitored at pH 5, 7, 9 and 11 respectively. In order to calculate the rate of fermentation, the volume of carbon dioxide produced during fermentation was measured over time. This was achieved by collecting and measuring the volume of carbon dioxide produced during fermentation in the inverted water-filled measuring cylinders (downward displacement of water) and the average rate of fermentation was calculated using the formula;

$$\text{Average fermentation rate} = \frac{total\ volume\ of\ CO2}{total\ time\ of\ fermentation}$$

Proximate analysis of fufu samples: The proximate analysis carried out on the fufu samples were moisture content, ash content, ether extract, crude protein, crude fibre and carbohydrate content were carried out using the Official Methods of Analysis by Association of Analytical Chemists. [13].

Sensory evaluation of fufu samples: Organoleptic properties of the 45 hours fermented and prepared fufu samples were evaluated subjectively by a set of 14 panelists drawn from the University community, made up of Master of Science degree and 400 level undergraduate Chemistry students. The selection of the panelists from the university environment was for practical convenience. The panelists were untrained and made up of males and females who have eaten fufu as a meal. All the samples were presented at the same time and the identities of the samples were not revealed to the panelists. Each panelist was provided with sufficient privacy to ensure that his/her result would be arrived at independently and without being influenced by other panelists [14]. The quality parameters of fufu evaluated were colour, smell, taste, texture and overall acceptability. A 5-point hedonic scale was used (i.e. 5-excellent; 4-good; 3-fair; 2-poor and 1-unacceptable). The panelists were to award a final score for overall acceptability.

Statistical analysis

Results obtained were then subjected to statistical treatment using the one way analysis of variance (ANOVA).

Results and Discussion

Fermentation is one of the oldest and most economical methods of producing and preserving foods. It is a dynamic process during which several catabolic and anabolic reactions proceed simultaneously, depending on several conditions, including substrate, microflora, and environmental factors. [15]. Because traditional fermentations are not carried out under controlled conditions products of variable compositions, taste and flavour are obtained.

Results of fermentation of cassava under different environment of pH are shown below. Figure1, shows the plot of volume of gas released versus pH as a measure of the effect of pH on the rate of fermentation. The results obtained from rate analysis shows a gradual increase in the rate of fermentation from pH 5 to pH 11, inferring that fermentation is faster in an alkaline medium than that obtainable in a neutral and acidic medium. It therefore means that the microorganisms responsible for fermentation of cassava can survive and thrive better in an alkaline medium. [16, 17].

Also, fermentation by lactic acid bacteria reduces the pH of a given medium to about pH 4 and below, which is unfavourable for their activities and growth. Hence, the alkaline medium may help to buffer or cushioning this acidic effect enabling the organisms to thrive better in an alkaline medium than the corresponding neutral and acidic medium.

Table 1, shows the results of organoleptic tests of fufu obtained from fermentation of cassava at different pH. The tests carried out are colour, taste, smell, texture and acceptability. The results subjected to further statistical treatment using a one way analysis of variance(ANOVA) show that there was no significant difference ($p > 0.05$) in colour, texture, taste and overall acceptability of the processed fufu samples, inferring that pH did not significantly affect 3 organoleptic properties of all the processed samples, though subjected to fermentation at varying pH. But $p < 0.05$ in the smell showing a change in the flavor of fufu produced at different pH. The results shows that the faster the rate of fermentation, the lower the odour of the processed fufu.

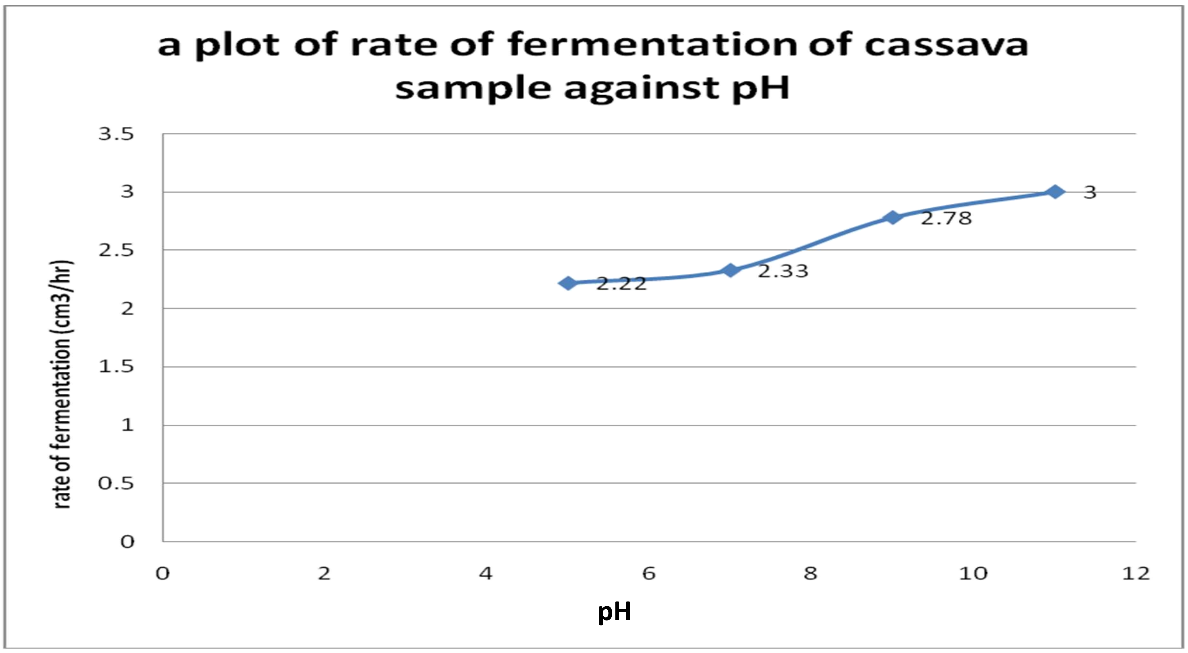

Fig. 1. The volume of gas generated at different pH of fermenting media

Table 1. Results of Organoleptic test on fufu produced

Sample	Colour	Taste	Smell	Texture	Acceptability
A	4.50±0.17	4.29±0.13	4.57 ± 0.23	4.07±0.32	4.36 ± 0.22
B	4.57 ± 0.14	4.14±0.10	4.36 ± 0.22	4.36±0.13	4.50 ± 0.14
C	4.64 ± 0.13	4.36±0.13	4.21 ± 0.21	4.21±0.21	4.50 ± 0.23
D	4.36 ± 0.13	4.07±0.25	4.21 ± 0.28	4.29±0.22	4.64 ± 0.13

Table 2. Results of pH of media at different times of fermentation

Sample	A	B	C	D
Initial pH (at commencement of experiment)	5.00	7.00	9.00	11.00
pH (after 45hrs of fermentation)	4.92	5.16	5.28	5.63
pH of fufu produced	5.59	5.60	5.63	5.68

Table 2, shows the pH of the medium during the course of fermentation. The table shows the pH of the medium at the commencement of fermentation, the pH after 45 minutes of fermentation and the pH of fufu at the end of fermention. After 45 hours of fermentation, the initial pH of 5,7,9 and 11 of the various medium, dropped to pH 4.92, 5.16, 5.28 and 5.63 respectively inferring the presence of volatile and non-volatile acids resulting from the fermentation process [18]. Also, the pH of the processed fufu samples (A, B, C and D) was slightly acidic (pH 5.59, 5.60, 5.63, and 5.68 respectively).

Table 3. Results of proximate analysis of the fufu samples

Sample	Moisture (%)	Carbohydrate (%)	Protein (%)	Ether Extract (%)	Crude fibre (%)	Ash (%)
A	70.00	22.61	0.70	0.36	6.00	0.33
B	72.00	21.19	0.53	0.45	5.50	0.33
C	70.67	22.44	0.70	0.36	5.50	0.33
D	68.67	22.41	0.70	0.36	5.30	0.33

Table 3, shows the proximate analysis of the fufu samples. The proximate analysis results of the fufu samples produced from different pH environment show no significant difference in moisture contents, ash content, crude fibre content, ether extract, crude protein content and carbohydrate content, inferring that pH did not signicantly affect the physico-chemical properties of the processed fufu samples.

Conclusion

This study has shown that pH only affected the rate of fermentation of cassava tuber, the flavor as there was considerabl reduction in the smell and not the other organoleptics and also physico-chemical properties of the processed fufu samples

Statistical treatment of results obtained from organoleptic analyses show no significant difference ($p>0.05$) in colour, taste, texture, and overall acceptability of all samples

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