Research Article

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DOI: 10.21767/2577-0586.100034

Journal of Food, Nutrition and Population Health
ISSN 2577-0586

2018
Vol.2 No.1:4

Physico-Chemical Characteristics and Storage Stability of Breadfruit and Cassava Co-Fermented into Gari Analogue

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Citation: Ajifolokun OM (2018) Physico-Chemical Characteristics and Storage Stability of Breadfruit and Cassava Co-Fermented into Gari Analogue. J Food Nutr Popul Health Vol.2 No.1:4

Abstract

This study concentrated majorly on producing a functional food; *gari* analogue from co-fermented breadfruit and cassava. A portion of both mature cassava tubers and matured but unripe breadfruit (*Artocarpus altilis*) was co-fermented (100:0, 0:100, 80:20, 70:30, and 60:40 Cassava: Breadfruit) to obtain *gari* analogue. The physico-chemical characteristics (pH, titratble acidity and cyanide content) of the fermenting mash were examined daily till the end of the fermentation days, also on the final *gari* analogue after production. The final *gari* analogue were stored in a plastic covered containers for six weeks during which pH, titratable acidity and cyanide evaluation were conducted weekly to determine if there could be any appreciable changes in acidity and taste of *gari* analogue samples. The pH of the samples decreased with increase in process time of the fermenting mash, breadfruits samples had lower pH than those cassava samples. Titratable acidity increased with increase in fermenting days as all samples had higher acid content at the end of fermentation period comparable with the initial acid content while the co-fermented *gari* samples had lower cyanogenic glycosides than 100% cassava *gari*. This study established that co-fermentation of breadfruit and cassava into analogue reduced the cyanogenic glycosides of *gari* with increase in titratable acidity (TTA) and decrease in pH values which in turn played a major role in altering the taste of the final *gari* analogue and its storage stability.

Keywords: Breadfruit; Cassava; Physico-chemical; Titratable acidity; Cyanide

Received: February 26, 2018; **Accepted:** March 22, 2018; **Published:** March 26, 2018

Introduction

Cassava *(Manihot esculenta*) is widely cultivated and consumed in tropical countries of Asia, South America and Africa where it is a staple food for many people (Cock, 1985). Cassava contains more than one form of cyanogenic glucosides, its uses as human food are limited by its perishability, low protein content and potential toxicity when not properly fermented. In West Africa, cassava is popularly eaten in fermented forms such as *gari, lafun, fufu* and starch [1-4].

Different varieties of cassava are generally classified into two main types: sweet cassava and bitter cassava. Sweet cassava roots contain less than 50 mg per kg hydrogen cyanide on fresh weight basis, whereas that of the bitter variety contains up to 400 mg per kg. Cassava roots can generally be made safe to eat by peeling and thorough cooking. However, bitter cassava roots require extensive processing. One of the traditional processes to prepare bitter cassava roots is through peeling, grating and fermentation which precede cooking in order to release the volatile hydrogen cyanide gas. Another process of preparing bitter cassava roots is through cutting, soaking and boiling in water; and this is particularly effective in reducing the cyanide content in cassava roots. Hence, adequately processed cassava based products with very low cyanide contents are considered safe to use by humans and for livestock feeds [5-24].

One of the most important staple foods in Nigeria is *gari* which is obtained from cassava. Gari is creamy white, granular flour with a slightly fermented flavour and sour taste. It is made from freshly harvested cassava tubers which are cleaned, grated, dewatered, left to ferment and then roasted. It is a staple food in many communities in West Africa [6]. *Gari* is by far the most popular form in which cassava is consumed in Nigeria and other West African countries [17].

However, it is very poor in nutrients especially protein (0.7 to 1.2%). Prolonged consumption of *gari* without adequate protein and other vitamins supplements will eventually lead to malnutrition. Therefore, providing cassava - based diets with supplemental high quality protein for adults and growing children may be necessary. One way this could be accomplished is by blending *gari* with breadfruit, which is relatively high in protein.

Gari is utilized in various ways and its consumption is on the increase due to the convenience of its preparation into several forms. The inclusion of certain percentage of cassava flour or starch in wheat flour and the utilization of cassava in biofuel production has increased the utilization of cassava and consequently affected the price of cassava products including *gari.*

Breadfruit (*Artocarpus altilis*), the seedless variety is a fruit producing plant which is native to Polynesia. The plant belongs to the *Moraceae* family of about 50 genera and over 1000 species. Breadfruit is propagated through stem-cuttings and the average first fruiting period of the crop is between 4 to 6 years [9]. It produces its fruits up to three times in a year and the number of fruits produced is very high. The fruit has been described as an important staple food of a high economic value. Although many people have heard of breadfruit, few have eaten it, hence, breadfruit is one of the underutilized fruits and it differs from other fruits because it has to be cooked before consumption.

Breadfruit is highly nutritious, cheap and readily available but is currently underutilized both at household and industrial level because of the way it is perceived by the society and its high perishability. Therefore, the co-fermentation of breadfruit with cassava into *gari* analogue with comparable physico-chemical and sensory qualities comparable to *gari* with low microbial load will increase the utilization of breadfruit as an analogue to cassava in *gari* processing hence the objectives of this study.

Materials and Methods

Freshly harvested matured but unripe breadfruits and matured cassava tubers were purchased at Ita-Osa market, Ile-Ife, Osun-State, Nigeria. Microbiological media and chemicals of analytical grade were procured from reputable scientific supplies store in Ile-Ife, Nigeria. Equipments were supplied by the Department of Food Science and Technology and Central Science laboratory, Obafemi Awolowo University, Ile-Ife, Nigeria.

Fermentation of breadfruit to *gari*

Matured green ripe breadfruits were weighed, washed, peeled and decored manually. Afterwards they were sliced manually into 1 cm thick slices. The slices were grated mechanically and the mash obtained was put in a bag and subjected to hydraulic press for 5 days (72 h) during which fermentation occurred and the juice drained off. The dried cake was then sieved and roasted in a metal pan over wood fire. The product obtained i.e., *gari* and *gari* analogue were packaged in polythene bags for further analysis. The flow chart for the production of breadfruit *gari* is shown in **Figure 1** [11].

Fermentation of cassava to *gari*

Cassava tubers were sorted manually to separate roots, leaves and debris; they were weighed and then peeled manually. The peeled tubers were thoroughly washed and grated with a mechanical grater. The mash obtained was put in a bag and subjected to heavy pressure for five days during which fermentation occurred and the juice was drained off. The *gari* produced was covered with plastic container for further analysis. The flow chart for the production of cassava meal is shown in **Figure 2** [5].

Co-fermentation of breadfruit and cassava into *gari* analogue

Three blends were prepared by weighing and mixing breadfruit mash and cassava mash in the following proportion of 80:20, 70:30 and 60:40. Others were 100% Cassava (control) and 100%

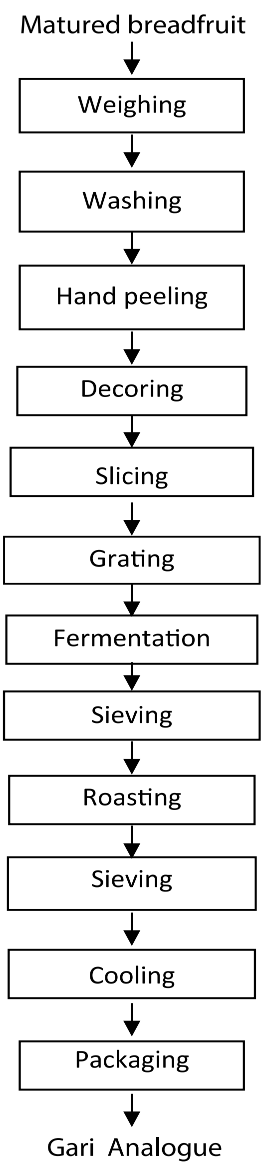

Figure 1 Process flow of *gari* analogue from breadfruit [11].

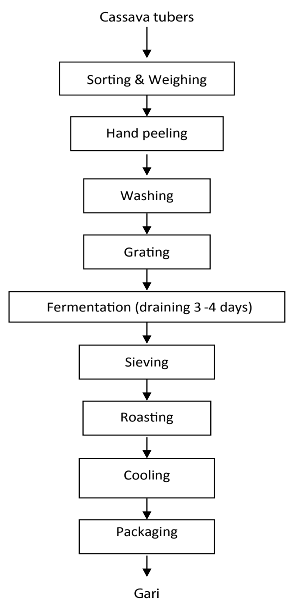

Figure 2 Process flowof *gari* from cassava tubers [5,14].

Breadfruit. As shown in **Figure 3.** Each of the blends obtained and the controls of the experiment were made to undergo microbiological, physical, chemical and sensory analyses.

Determination of pH

pH or hydrogen ion concentration of each sample was measured with a standard meter (ATC, model HI-8915). The pH meter was standardized with standard buffers of pH 4 and pH 7. pH was determined by making a 10% w/v suspension of the sample in distilled water. The suspension was mixed thoroughly and the probe of the pH meter that had been subjected to calibration with buffer 7 was introduced into each. Readings were taken when the readings were stable [10].

Determination of titratable acidity

Titratable acidity (expressed as lactic acid) was determined using the method [13]. Homogenate of the sample was prepared like that of pH determination. The slurry was filtered through Whatman No 1 filter paper. Aliquot (10 mL) was titrated with 0.1 M NaOH using phenolphtalene as the end point indicator. Three drops of 0.1% phenolphtalene indicator was added to flask and was mixed thoroughly before titration with 0.1 M NaOH. Titration was continued until a permanent pink color was observed. In each case, titratable acidity was expressed as lactic acid as follows; 1 mL of 0.1 M NaOH=0.009 g of lactic acid

Determination of cyanide content

Hydrogen cyanide content of *gari* was determined according to a procedure of Rosling [23]. Ten grams of each sample was put into a kjeldahl bottle and into each was added 10 mL of distilled water. This was incubated at room temperature for 2 h. Thereafter, 100 mL of distilled water was added and the samples were distilled. Exactly 130 ml of the distillate wad added in an Erlenmeyer flask and was filled with 20 mL of 2.5% NaOH. Thereafter, 8 ml of NH_4OH and 5 mL of 5% KI were added. Finally, the distillate was titrated against 0.02N $AgNO_3$ until the color changed indicating the titre point. HCN content was calculated using the equation:

Storage of *gari* and *gari* analoque

All the *gari* samples were stored at ambient temperature in an air tight container for a period of six weeks. On a weekly basis, the pH and TTA were determined using the methods described above. Total viable count, yeast and mould count and lactic acid bacteria counts were also determined using the methods [15,16].

Results and Discussion

pH of sample

Results of pH readings of all the samples during fermentation are presented in **Figure 4.** The pH of all the samples decreased with increase in process time of the fermenting mash although breadfruit had pH values that were lower than those of cassava. One hundred percent cassava *gari* has the lowest decrease in pH value of 5.90 on the initial day to 3.69 on the final day, this is a difference of 2.21 while 70:30% *gari* mash decreased from 6.91 on day zero to 3.68 on the fifth day, with a difference of 3.29. This is as a result of production of organic acid during fermentation which was responsible for the sour taste, a unique characteristics of *gari* [8]. The more the acid produced the lower the value of the pH. Apart from this, pH changes during this study followed the typical pattern [20] for *gari* fermentation, where there is a rapid drop of pH within the first 24 h followed by very minimal changes up to the end of fermentation.

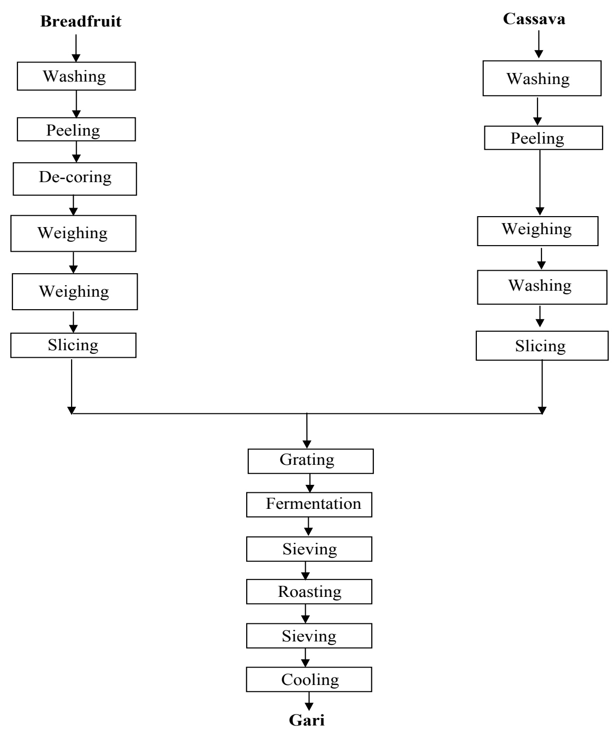

Figure 3 Process flow for the co- processing of breadfruit and cassava tuber into *gari.*

Titratable acidity of samples

The titratable acidity of all the samples during fermentation ranged between 0.0016 and 0.0061 mg/g lactic acid**.** It was observed that the acidity increased with increase in the number of fermentation time. Titratable acidity of 100% cassava *gari* increased from 0.0018-0.0061 (mg/g) lactic acid. All samples were observed to have higher acid content at the end of the fermentation period as compared with the initial acid content. Production of organic acids by LAB on starch substrates could be responsible for the decrease in pH and increase in TTA [19]. Increase in acidity could play a role in the preservation of the fermented products and could also alter the taste of the final *gari* products [3].

Cyanide content of samples during fermentation

Figure 5 shows the result of cyanogenic glucosides of *gari* samples. The 100% cassava *gari* has the highest content of cyanogenic glucosides of 13.72 mg/HCN/Kg while 100% breadfruit *gari* has the lowest content of 8.1 mg/HCN/Kg. The co-fermented *gari* samples had lower cyanogenic glucosides than 100% cassava *gari*. The presence of breadfruit has really reduced the cyanogenic glycosides of *gari*. The cyanide content of all the samples are within the same range with the data earlier reported for some cassava products of (10.5 mg/HCN/Kg [4,21,22]. Moreover, the cyanide levels are far below the detrimental level of 30 mg/kg [6]. These products could therefore be considered safe with regard to cyanide poisoning. Co-fermentation of cassava and breadfruit in production of *gari* analogue is an effective way of obtaining *gari* products of extremely low level of Hydrogen cyanide.

When plant tissues are crushed (mashed roots), the plant cell structure may be so damaged that the enzymes can meet with and act on the cyanogenic glycoside [12]. The action of linamarase on Linamarin and Lotaustralin are the hydrolytic release of acetone cyanohydrins and 2-butanone which is unstable. Fermentation has greater effect on the cyanide value by reducing it to a minimal extent. Production of cyanogenic compound is caused by disruption of structural integrity of plant cells during peeling of cassava tuber, thus, allowing the cyanogenic glycosides from vacuole to come in contact with the enzyme linamarase on the cells wall [7]. Cyanide is very poisonous because it binds cytochrome oxidase and stops its action in respiration, which is a key energy conversion process in the body. The lethal dose for an adult depends on body weight and is between 30 and 110 mg of hydrogen cyanide. Sometimes persons eating a cassava meal exceed these limits and death occurs due to cyanide poisoning. Smaller (non-fatal) amounts of cyanide cause acute intoxication with symptoms of dizziness, headache, stomach pains, vomiting and diarrhea [13].

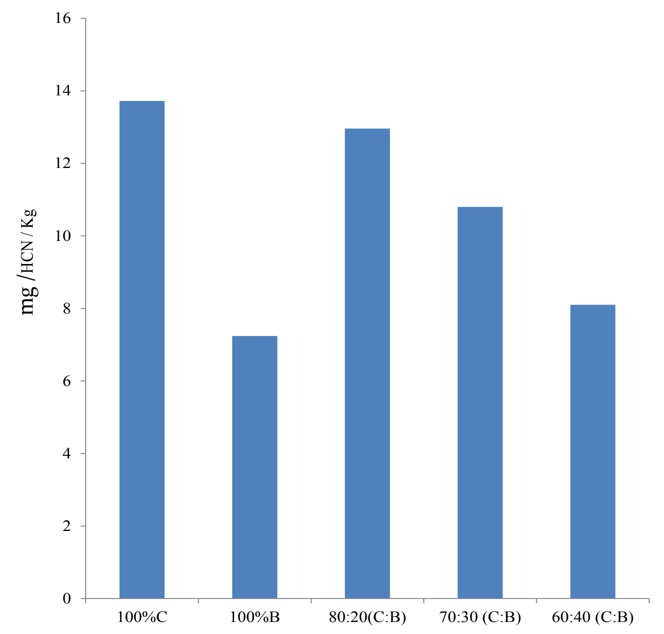

Figure 5 Cyanide content of *gari and gari* analogue samples.

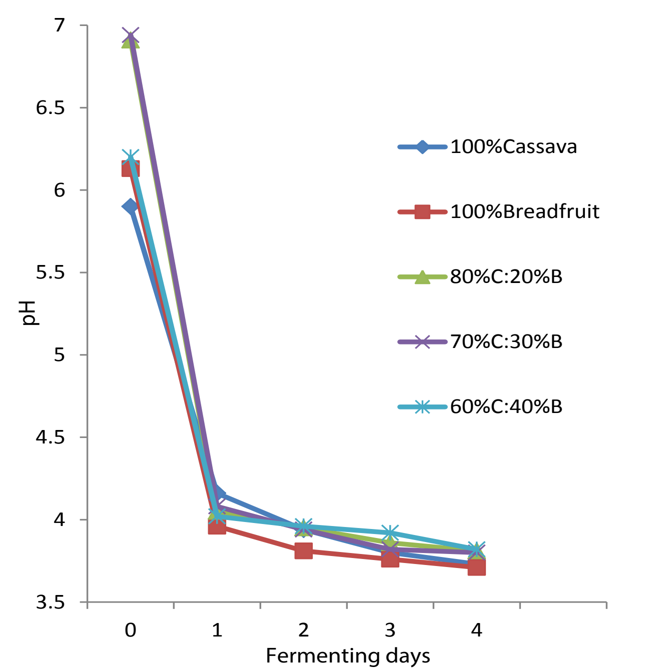

Figure 4 pH of the co-fermented cassava and breadfruit meal during fermentation.

Chemical analysis of *gari* during storage

pH of *gari* during storage: The pH of all the samples was discovered to also be decreasing gradually during the storage period from the first week till the last week. The gradual decrease in pH obtained in all samples during the study might be attributed to the production of acidic metabolites by microorganisms during growth and proliferation [8]. The final pH of the *gari* was above the recommended pH (3.9-4.3) [1]. High pH is rather undesirable in *gari* as it might predispose the product to bacterial spoilage.

Titratable acidity of stored *gari* samples

The titratable acidity of all the samples within the storage period ranged between 0.0010 and 0.001 mg/g lactic acid and the details of the analysis. Titratable acidity increased in response to increase in acidity. Titratable acidity of the *gari* was significantly affected by the fermentation days [3].

Conclusion

The study explored the potentials of substituting breadfruit into cassava to obtain *gari* analogue. Cyanide value of the co-processed *gari* was lower comparable to 100% cassava *gari.* pH value of the *gari* increased with decrease in titratable acidity. Storage did not produce any appreciable changes in its physic-chemical properties for the period of six weeks. Co-fermentation of cassava and breadfruit in the production of *gari* analogue is an effective way of obtaining *gari* products of extremely low level of hydrogen cyanide. Thus, this product is considered a safe and convenient functional food for consumption in African countries and other countries where *gari* is consumed so as to reduce malnutrition and food poisoning as well as promoting utilization of breadfruit.

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