Effect of the Duration of Fermentation on the Quality of Gari

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Abstract: The effect of duration of fermentation on some proximate and sensory parameters was studied in bitter cassava grated and fermented traditionally for a period of five days to determine the optimum number of days of fermentation for best quality gari. The statistical design used in studying the effect of duration of fermentation on moisture content, ash content, crude fibre, crude protein, hydrogen cyanide (HCN), swelling index, HCN and crude fat was Complete Randomized Design (CRD) with three replications. Standard procedures were used in the determination of all the parameters studied. A panel of thirty judges were invited for the sensory evaluation of colour, aroma and texture. The results of the study as indicated by analysis of variance show that there is highly significant effect (P < 0.01) of the duration of fermentation of gari on moisture content, ash content, crude fibre, crude fat, crude protein, HCN and swelling index. The regression analysis indicates that whereas moisture content, ash content, crude fibre, crude protein, HCN and swelling index generally seems to increase with increase in duration of fermentation, HCN and crude fat decreased with increase in duration of fermentation. The study recommends that for industry application, cassava mash for gari should be fermented for at least three days. Cassava mash fermented for three days has the HCN reduced to a level tolerable for human consumption; there is an advantage of maximum swelling, in addition to desirable colour, aroma and texture.

Key words: Duration, fermentation, gari and quality

INTRODUCTION

Cassava (Manihot esculenta crantz) is a staple food for over 500 million people in the developing world (Cock, 1985). In Nigeria, it appears to be the major staple food that matches the population growth. Nigeria’s cassava production is by far the largest in the world, a third more than production in Brazil and almost double the production of Indonesia and Thailand (FAO, 2006). The Food and Agriculture Organization of the United Nations in Rome estimated 2002 cassava production in Nigeria to be approximately 34 million tonnes which in comparison with other crops ranks first, followed by yam production at 27 million tonnes, sorghum at 7 million tonnes, millet at 6 million tonnes and rice at 5 million tonnes (FAO, 2005). Cassava roots are highly perishable and cannot be kept in fresh condition for more than a few days after harvest without serious deterioration in quality (Leakey and Wills, 1977). In order to extend the shelf life of the roots, cassava is processed into dried products in a variety of ways in different parts of the world to meet the local needs, taste and tradition for use and storage (Ingram and Humphries, 1972; Onwume, 1978). Of all these, the main form in which cassava is eaten in West Africa is a roasted granular product prepared from peeled, grated and fermented cassava roots, known as gari (Asiedu, 1989). The cassava root is processed into wet chips, elufo from cassava flour, fufu (akpu) from cassava starch and gari (eba) (NRCRI, 1987). Traditionally, cooked gari and fufu are always served with rich vegetable soup. As a snack, boiled cassava is taken with roasted groundnut, coconut, fish or meat. Traditionally, cassava salads are very good combinations of highly nutritious food stuff such as ‘abacha’ (cassava noodles) and wet chips and are often more than snacks. Thus the emphasis on protein deficiency of cassava is due to ignorance of food habits in regions where cassava is the people’s main food (Ihekoronye and Ngoddy, 1985) Cassava is also used for the production of textiles, starch, adhesives, alcohols and acetone (NRCRI, 1987).

Gari is a convenience food with a short preparation time. Its cheapness, ease of storage and preparation for consumption have combined to make it extremely popular among the urban dwellers in Nigeria and other West African countries. A versatile product, gari can be prepared in a variety of ways. It can be dispersed in cold water and consumed directly with sweeteners, groundnut and fish. The most widespread method of gari consumption is preparing it into a paste by pouring into a measured quantity of boiling water. The paste, popularly called eba in Nigeria is eaten by dipping small balls of it into soup or stew and swallowing with or without mastication. Gari is by far the most popular form in which cassava is consumed in West Africa (Onwume, 1978). In Nigeria, it is consumed primarily by the urban dwellers and the scale of gari processing in West Africa has been found to involve individual family units producing less than 0.5 ton/hr. The end product (gari) is consumed in varying amounts by approximately 50 million Nigerians (NRCRI, 1987). Whether gari can be relied upon as staple
food will to a large extent depend on how well it can be processed in safe forms (Bokanga, 1995). Market expansion for gari, to some extent, depend largely on the degree to which the quality of the processed gari can be improved upon to make it attractive to potential consumers. Quality is the degree of excellence and acceptance. Products with superior quality can get higher prices and can also sell larger quantities. The quality of gari available in the local market varies from batch to batch among the traders. Variations are observed in the colour, fiber content, moisture, particle size, starch content and residual cyanide. These variations are caused by cassava variety, age at the time of harvest, processing methods and equipment, and duration of fermentation.

The use of cassava as a food is limited by its perishability, low protein content and potential toxicity (Cooke and Coursey, 1981). Processing methods have been devised to reduce their toxicity and at the same time convert the highly perishable roots to more stable products. These processes include sun drying, soaking and fermentation followed by drying or roasting.

The toxicity is due to the cyanogenic glucosides, linamarin and lotaustralin present in all parts of the plant with the possible exception of the seeds (Coursey, 1973). Fermentation is one method by which cyanogenic glucosides in gari can be reduced. Fermentation also results in the production of volatile compounds that give gari its unique flavour. Most of the juice from the cassava pulp is expressed during this period. The time allowed for fermentation is critical; too short and the detoxification process is incomplete, resulting in a potentially toxic product, too long and the product will have a strong sour taste and the texture will be poor (Azam-Ali et al., 2003). Commercial gari processors in Nigeria ferment for different durations. Collard and Levi (1959) reported that the acceptability of gari is influenced by its sourness and is directly related to the degree of fermentation. Akinrele (1964) reported that hydrogen cyanide is liberated during fermentation through the spontaneous hydrolysis of the cyanogenic glucosides of cassava at low pH. The cyanogenic glucoside content of gari is an important quality parameter of gari, due to its toxicity, if consumed in amounts greater than 30ppm (Olarewaju and Boszoromanyi, 1975). If processing is adequate, the cassava roots will be detoxified from about 300mg hydrogen cyanide (HCN) per kg fresh weight of cassava to 10mg/kg (Akinrele et al., 1962). Of interest is the report that gari toasted with palm oil contains practically no detectable cyanide. Ukpabi and Ndimele (1990) reported that moisture content was directly related to the aggregate sizes and that gari with aggregate sizes greater than or equal to 1 mm and moisture content greater than or equal to 16% did not store well and showed decreased swelling index. In recent years, consumers have placed increased emphasis on food safety and expect that food would not contribute to chronic diseases. The expectation of food supply include that it be nutritious, wholesome, pure and safe. Therefore, investigation into an appropriate duration of cassava fermentation that will yield the best quality of gari is imperative.

**MATERIALS AND METHODS**

This study was carried out in March 2008 in the Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi, Nigeria. Cassava tubers obtained in Makurdi were immediately peeled, washed and allowed to drain, after which the tubers were grated using locally manufactured perforated meal sheet. The grated meals were bagged in a cloth sack and heavy stones placed on the sack for dewatering while it fermented for a period of five days. For the five days that the fermentation lasted, a quantity from the mash was taken, sieved, fried and analyzed for proximate and sensory parameters.

The proximate composition of each sample of gari was determined using standard analytical procedures. The amount of HCN was calculated in milligram per kilogram of gari based on AOAC (1984) method. The ash content of the samples were also determined similarly using methods described in AOAC (1984) after burning the gari sample on a Bunsen burner and incinerating the charred material in a muffle furnace set at 550°C until a whitish grey ash remains, then cooling in a desiccator and weighing. The percentage moisture content of the gari was determined based on weight loss of water due to evaporation during drying in an oven at 50°C for four hours until constant weight is obtained. The sorghum extraction method as described by Egan et al. (1981) was used in determining the crude fat. The extraction under reflex was carried out with petroleum ether at a temperature range of 40-60°C for 5 hours, followed by drying in an oven at 30mins at 100°C for the solvent to evaporate, cooling and weighing. Crude fibre was determined as difference between the oven dry weight and weight afterashing divided by the sample weight while crude protein was determined using the kjedahl method.

In determining the swelling test, 25mg of gari was measured into a 100ml measuring cylinder. The measuring cylinder was then filled with water to 100ml bench mark. The measuring cylinder was shaken several times and allowed to settle. The volume of the gari was recorded after 15 minutes. The percentage swelling in the volume was determined by the difference in volume divided by the initial volume.

For the sensory evaluation (colour, aroma and texture), the gari obtained on zero fermentation was poured into container labelled 0th day, gari of the 1st day of fermentation into container labelled 1st day, gari of the 2nd day of fermentation into the container labelled 2nd day, and so on till all the six containers were filled with gari. A panel of thirty judges were invited for the sensory evaluation of colour, aroma and texture. The samples in the container were presented to the judges at random. The judges were asked to award scores for each sample after observing the colour, aroma and texture of each sample of
Table 1: Proximate, sensory and regression analysis as affected by duration of fermentation (days)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Duration of Fermentation (Days)*</th>
<th>Linear Regression Equation</th>
<th>R²</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Crude fibre (%)</td>
<td>2.70</td>
<td>2.70</td>
<td>2.35</td>
<td>2.70</td>
</tr>
<tr>
<td>Swelling test (%)</td>
<td>225</td>
<td>300</td>
<td>355</td>
<td>400</td>
</tr>
<tr>
<td>HCN content (mg/kg)</td>
<td>12.67</td>
<td>9.48</td>
<td>7.60</td>
<td>5.72</td>
</tr>
<tr>
<td>Moisture content (% w.b)</td>
<td>8.98</td>
<td>10.91</td>
<td>10.83</td>
<td>10.55</td>
</tr>
<tr>
<td>Ash content (%)</td>
<td>1.87</td>
<td>1.69</td>
<td>2.20</td>
<td>1.65</td>
</tr>
<tr>
<td>Crude fat (%)</td>
<td>3.23</td>
<td>2.91</td>
<td>2.82</td>
<td>2.60</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>2.33</td>
<td>2.40</td>
<td>2.45</td>
<td>2.55</td>
</tr>
<tr>
<td>Colour (%)</td>
<td>13.3</td>
<td>72.4</td>
<td>82.5</td>
<td>85.3</td>
</tr>
<tr>
<td>Aroma (%)</td>
<td>20.7</td>
<td>57.1</td>
<td>78.3</td>
<td>79.8</td>
</tr>
<tr>
<td>Texture (%)</td>
<td>28.6</td>
<td>68.5</td>
<td>80.8</td>
<td>83.8</td>
</tr>
</tbody>
</table>

*Values of sensory attributes are means of 30 panelists while all other values are means of triplicate measurements

R² = coefficient of determination, r=correlation coefficient, D= duration of fermentation (days)

Table 2: Summary of ANOVA for proximate parameters as affected by duration of fermentation (days)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degree of Freedom</th>
<th>Moisture Content (% w.b)</th>
<th>HCN content (mg/kg)</th>
<th>Swelling test (%)</th>
<th>Ash content (%)</th>
<th>Crude fibre (%)</th>
<th>Crude fat (%)</th>
<th>Crude protein (%)</th>
<th>5%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of Fermentation (Days)</td>
<td>5</td>
<td>779.065**</td>
<td>1802.44**</td>
<td>7675**</td>
<td>42.734**</td>
<td>123.464**</td>
<td>115.008**</td>
<td>38.936**</td>
<td>3.11</td>
<td>5.06</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

**Highly significant difference (1%)**

gari. The best sample had 6 points, the next in quality 5 points, and so on. The least had 1 point. The total points for each of the samples were added.

**Experimental Design:** The experimental design for the study on the effect of duration of fermentation on moisture content, ash content, crude fibre, crude protein, HCN, swelling index, HCN and crude fat is Complete Randomized Design (CRD) with three replications. The Analysis of Variance (ANOVA) and regression analyses were carried out using Microsoft Office Excel 2007.

**RESULTS AND DISCUSSION**

From the result of the proximate analysis of gari sample shown in Table 1, it was observed that the HCN content decreased with increase in days of fermentation with highly correlated r value of 0.9743. The analysis of variance indicates highly significant effect (P<0.01) of HCN as affected by duration of fermentation (Table 2). This could be as a result of two reasons: Firstly, the grating of the peeled cassava roots/tubers to obtain the mash disrupts the structural integrity of plant cells, thus allowing the cyanogenic glucosides from storage vacuoles to come in contact with the enzyme linamarase on the cell wall (Bokanga, 1995). 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 glucoside (Bokanga, 1995). The action of linamarase on linamarin and lotaustralin is the hydrolytic release of acetone cyanohydrin and 2-butanoine which is unstable. At pH above 5, they spontaneously decompose to the corresponding ketone and HCN which is lost by volatilization (Bokanga, 1995). The second reason could be the high temperature at which gari is roasted and dried. The heat resulting from high temperature reduced the HCN content of the gari. This is in agreement with the observation of Meuser and Smolnik (1980) on the effect of heat on hydro cyanic acid content. Generally therefore, gari should be properly dried as a well dried gari would have the HCN ‘burn off’ in heat during the drying process because heat destroys HCN.

The duration of fermentation also had highly significant effect (P<0.01) on the moisture content of the gari (Table 2). However, the r value is very low as shown in Table 1. This indicates a very poor relationship between moisture content and duration of fermentation. Moisture removal in gari is a function of many factors such as temperature, time, humidity, etc. The available moisture in gari solely depends on the degree of dryness during frying. Generally, a well dried gari stores well as there would be no free moisture to encourage microorganisms multiplication in gari which otherwise would have had adverse effect on the quality of gari.

The analysis of variance further indicates that there is a highly significant effect (P<0.01) of duration of fermentation on crude fibre content of gari (Table 2) with a correlated r value of 0.6637 (Table 1). Generally, there appears to be an increase in crude fibre as duration of fermentation increases. The duration of fermentation also had highly significant effect (P<0.01) on crude fat (Table 2) with highly correlated r value of 0.9608 (Table 1) indicating that crude fat decreased with increase in duration of fermentation. At the onset, i.e. 0th day, the crude fat value was 3.23%. On the 1st day of fermentation, the value decreased to 2.91% and it further decreased to 2.82% on the 2nd day. The decreasing trend did not abate on the 3rd day as it further decreased to 2.60% and continued until it finally fell to 2.48% on the 5th day of fermentation. This behavior could be attributed to the rising temperature of fermentation. As fermentation duration increases the temperature also increases (Collard and Levi, 1959). Temperature is known to have an effect on physical characteristics of food fats. Weiss (1983) has established that as temperature increases the solid fat index of certain foods.
decreases. Temperature could probably be the reason for the rate of decrease of crude fat in garri.

The result of the study further indicates that increase in days of fermentation appears to have highly significant effect (P<0.01) on the crude protein content in the samples (Table 2). The crude protein increased with increase in duration of fermentation between the 0 and 3rd day but decreased with increase in duration of fermentation afterwards, thus giving a correlated r value of 0.7899. The duration of fermentation had a highly significant effect (P<0.01) on the ash content (Table 2) which generally appears to increase with increase in duration of fermentation (Table 1). The results shown in Table 2 indicate that swelling index of garri is highly affected by duration of fermentation (P<0.01). The swelling index increased with increase in duration of fermentation from 225% on day zero to 400% on day 3 and remained constant afterwards (Table 1). Carmago et al. (1988) reported that the organic acids and amylase released by micro-organisms degrade starch granule. A breakdown of starch granules invariably loosens up the starch network and allows for a higher moisture absorption capacity. It could therefore be assumed that prolonged fermentation periods (up to 3 days) for proper degradation of starch led to a higher absorptive/swelling capacity of the garri on reconstitution.

The effect of duration of fermentation on the colour, aroma and texture of garri is shown in Table 1. From the percentage sensory evaluation of garri samples, it could be seen that the garri fermented between 3-5 days yielded best quality. The garri fermented for 3 days have the desirable colour and aroma while the garri fermented for 4 days was voted the best garri with the best texture.

CONCLUSIONS

The following conclusions may be drawn from the study:

- There is highly significant effect (P<0.01) of the duration of fermentation of garri on moisture content, ash content, crude fibre, crude fat, crude protein, HCN and swelling index.

- Whereas moisture content, ash content, crude fibre, crude protein, HCN and swelling index generally seems to increase with increase in duration of fermentation, HCN and crude fat decreased with increase in duration of fermentation.

- The garri of best quality was obtained from the mash fermented for 3 days. The garri was the best in terms of colour and aroma, the garri fermented for 4 days was the best in terms of texture.

REFERENCES


