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Full Length Research Paper

Effect of rehydration and fermentation methods on the quality of *garri* produced from stored cassava chips

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***Garri* was produced from cassava chips stored over 3 months by milling the chips before rehydration and mash fermentation by the traditional method (MRT) or backslopping (MRB). Chips were also rehydrated before milling, fermented traditionally (RMT) and then roasted, while *garri* from fresh cassava tubers fermented traditionally served as control (C). The *garri* samples were evaluated for pH, cyanide content and sensory acceptability. *Garri* produced from chips by the RMT method gave pH values of 4.25 on month 0 and increased to 4.91 after 3 months; MRT and MRB decreased from 3.42 to 2.91 and 3.36 to 3.13 respectively. The control *garri* had a pH of 3.83. The cyanide content of control *garri* was 100.8 mg/kg; RMT ranged from 67.44 to 65.28 mg/kg; MRT, 79.20 to 67.88 mg/kg and MRB, 72.00 to 56.88 mg/kg. Sensory rating indicated that RMT *garri* were best accepted within the first 2 months during which they also had the highest pH and the lowest cyanide content. MRB *garri* was most accepted at the third month; it had intermediate pH values while the cyanide content was lowest at the second and third months.**

Key words: Cassava chips, rehydration, fermentation, *garri*, pH, cyanide content, sensory attributes.

INTRODUCTION

Garri is a creamy white, starchy, pre-cooked grit produced by fermentation of peeled, washed and mashed cassava roots which are dehydrated, sieved and roasted (Onyekwere, 1989), In Nigeria, over 70% of the cassava yield is processed into *garri* (Sanni and Olubamiwa, 2004). Its ability to store well and its acceptance as a convenience food are responsible for its popularity in West and Central Africa where it is a staple food. It is often consumed as a main food meal in the form of a dough or thin porridge. It swells three to four times its volume when mixed with cold water (Grace, 1997).

The acceptability of *garri* is based on: organoleptic (colour, taste, aroma, absence of extraneous matter, and texture); physical (swelling capacity, particle size distribution); and chemical (pH, water activity and residual HCN) properties (Ajibola et al., 1987). The most important properties include: appearance - white or yellow (if palm oil is added); sour taste (total acidity >1% lactic acid), gritty texture, dryness (moisture content not more than 10%, w/w) (Steinkraus, 1989) and residual hydrogen cyanide (HCN) level less than 50 mg/kg (Purseglove, 1991).

The HCN content derives from the potentially toxic cyanogenic glucosides (linamarin and lotaustralin) which on hydrolysis give glucose, the toxic hydrogen cyanide (HCN) and acetone or propanone. The consumption of improperly processed cassava with high cyanogen content has been associated with cretinism, endemic goiter (Ermans et al., 1980; Delange et al., 1983) and even death. In addition to the toxic effect, the use of cassava roots as food is limited by their low protein content, short shelf life (Westby, 2002) and seasonal variability. The latter makes the cost of *garri* to increase occasionally in the year particularly during the pre-planting and planting seasons.

The traditional processing technique for *garri* production (Grace, 1997) has been modified to include: (a) addition of water to the fresh grated cassava at 75% (v/w) level, heating at 50°C for 6 h and equilibrating with a 3-day fermented cassava liquor (40% v/w) for 12 to 18 h, dewatering and toasting (Sokari, 1992), (b) the fresh tubers are peeled, washed, sliced and dried into chips which are then milled and fermented (Oguntimein, 1992),

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or rehydrated by addition of water and fresh cassava mash (FIIRO, 2004) fermented, dehydrated and sieved before roasting to produce *garri*. The use of dry cassava chips not only offers the advantage of longer shelf-life of the raw material, much easier and leisurely handling but also reduces the cyanogenic glucoside content (Best, 1978; Gomez and Valdivieso, 1984).

Work in our laboratories (Uvere et al., 2009, 2010) has shown that backslopping (Nout et al., 1989) is a very effective fermentation technique and could be resourcefully applied to *garri* production. This project was therefore designed to study the effects of rehydration and fermentation methods on the sensory and some chemical qualities of *garri* produced from dried cassava chips stored over three (3) months.

MATERIALS AND METHODS

Cassava tubers *(Manihot esculenta* Crantz, TMS 30577) were obtained from the KUL–UNN Linkage Farm, University of Nigeria, Nsukka, Nigeria after one and half ($1^1/_2$) years of planting and used for this study.

Production of *garri* from stored, dried cassava chips and fresh cassava tubers

The cassava tubers were harvested early in the morning, peeled, washed and cut into chips of approximately 3×1.5×1 cm within 3 h. The chips were dried under the sun (average temperature = 28.5±3℃) on concrete floors (Best, 1978; Gomez and V aldivieso, 1984) at an air flow rate of 33 m/s and average relative humidity (R. H) of 74%. The drying process lasted for 72 h during which the chips were turned every 2 h (except at night) to ensure drying to a moisture content of 13.57%. The chips were then packed in nylon woven sacks (Okpokpo Industry, Onitsha, Nigeria) and stored in 7 kg packs under well ventilated room conditions (37±2°C; R.H. = 97.5%).

At the end of each month of storage, 7 kg of the stored chips was divided into three portions (2.3 kg each) and rehydrated by either of two methods: rehydration of chips before milling or milling of dried chips followed by rehydration. Portion 1 was rehydrated in 5.2 L of clean tap water for 24 h to achieve an average moisture content of 57% before milling and traditional fermentation (RMT). Portions 2 and 3 (2.3 kg each) were milled and separately mixed with water; portion 2 was mixed with 5.2 L of water and fermented by the traditional method (MRT) while portion 3 was mixed with a total of 5.2 L of water and fermented by backslopping (Nout et al., 1989). Fermentation of mash portions 1 (RMT) and 2 (MRT) by the traditional method involved bagging the mash, fermentation and dewatering under a hydraulic press. Each stock of cassava mash was fermented for 72 h (Meuser and Smolnik, 1980) at ambient temperature (31±2℃).

After backslopping fermentation, the cassava mash (Portion 3) was dried under the sun (31±2℃) until it formed lump s (in 96 h) that when mashed, ran freely in the hand. The three dehydrated samples were sieved and roasted in a shallow aluminium pan over wood fire at 140 to 150℃ for 15 to 20 min.

Quality assessment

The *garri* samples were assessed for pH, cyanide content and sensory acceptability. The pH was determined with an Expandable Ion Analyser, EA 920 (Orion Research Incorporated, Cambridge, USA). Total cyanide was determined potentiometrically (AOAC, 1995) using an Expandable Cyanide Ion Analyser EA 920. Cassava peel linamarase and the parenchymal extract used for cyanide analysis were prepared according to the methods of Cooke (1979). Sensory evaluation based on a 7-point hedonic scale (1 = disliked very much; 7 = liked very much) was used to evaluate the *garri* for appearance, taste, texture and general acceptability; A 100-member panel consisting of 50 males and 50 females who consume *garri* as a food staple were used for the evaluation.

Each determination was carried out three times and the means and standard deviation calculated. Data obtained were analysed for sample differences based on a randomised complete block design (RCBD) using analysis of variance (ANOVA) and least significant difference (LSD) at $p<0.05$.

RESULTS AND DISCUSSION

Garri yield/process loss

Chip production from the 200 kg of cassava resulted in the loss of 79.3% of the raw material and could be attributed to losses resulting from peeling, dehydration and loss of chips during drying. When the chips were used to produce *garri*, the yield was 38.8 kg giving a process loss of 1.3 and 80.6% relative to the chips and fresh cassava tubers respectively. The *garri* produced weighed 38.8 kg which is some 19.40% yield from the fresh cassava. The additional loss of 1.3% when *garri* was produced from chips could be accounted for by loss of starch during storage (Abera and Rackshit, 2004) and by losses during milling, fermentation and loss of volatiles during roasting.

The 19.4% yield obtained is lower than the 21 to 34% reported by Achinewhu et al. (1998) or the lowest value of 20.93% (Karim et al., 2009) for fresh and stored cassava roots respectively. The differences could be due to losses during chip production.

pH

The pH of *garri* produced by the RMT method increased from 4.25 to 4.91 as the storage period of the dried cassava chips increased from 0 to 3 months (Figure 1). The increase in pH of *garri* produced by the RMT method is probably due to loss of HCN and organic acids during dewatering and roasting. In MRT and MRB, the pH decreased from 3.42 and 3.36 to 2.91 and 3.13 respectively during the 3 months of chip storage. *Garri* produced by MRB had pH values intermediate between RMT and MRT; MRB and MRT had pH values less than that of *garri* from fresh cassava.

In MRT, the heat of milling before rehydration possibly inactivated more linamarase activity leading to reduced rate of HCN production. This may have permitted an earlier relief from cyanide inhibition of fermentation microorganisms (Zintgraff et al., 1969) resulting in more acids produced and consequently, lower pH. *Garri*

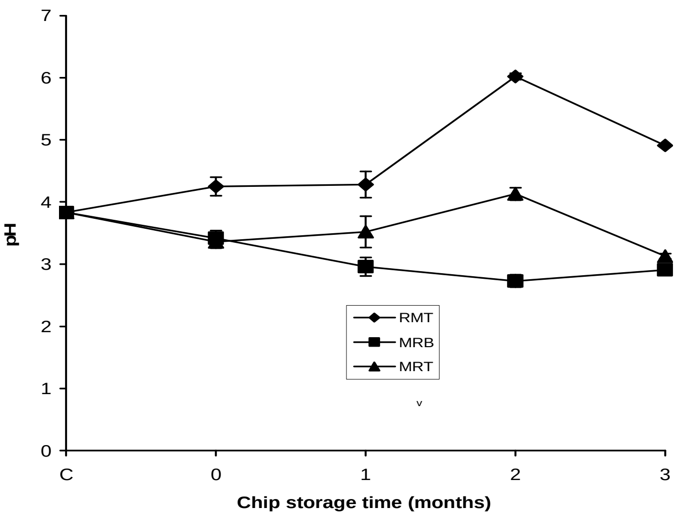

Figure 1. pH of *garri* from fresh cassava and stored chips. C - Fresh cassava; RMT-rehydrated chips milled and traditional fermentation; MRB - chips milled, rehydrated and backslopping fermentation; MRT - chips milled, rehydrated and fermented traditionally.

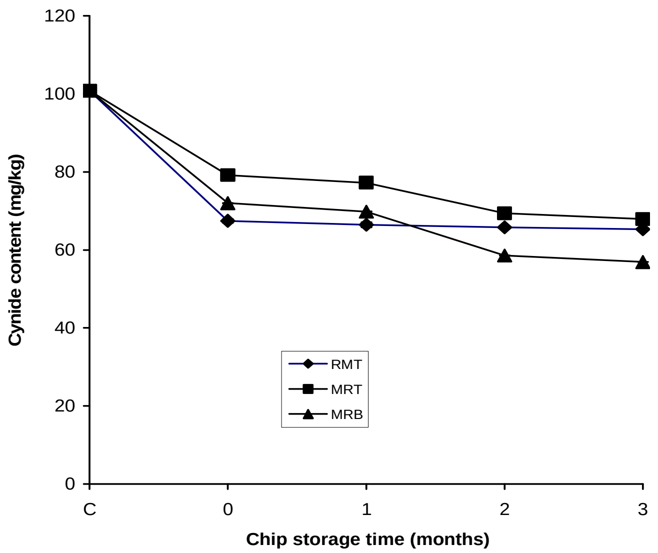

Figure 2. Cyanide content of *garri* from. C - Fresh cassava; RMT-rehydrated chips milled and traditional fermentation; MRB - chips milled, rehydrated and backslopping fermentation; MRT - chips milled, rehydrated and fermented traditionally.

produced by MRB had pH values intermediate between RMT and MRT possibly because the backslopping method may have encouraged the production of lower amounts of organic acids. Except for sample RMT which had higher values, the pH values reported here are lower than or within the range (3.4 to 4.0) reported by Achinewhu et al. (1998) but they were lower than the 4.19 to 4.58 of Owuamanam et al. (2011).

Total cyanide content

The total cyanide content of *garri* samples produced from dried and stored chips (Figure 2) decreased and tended to level off by the 3rd month of chip storage. All the chip *garri* samples had lower total cyanide compared to *garri* from fresh cassava roots possibly resulting from losses during chip production and storage (Omueti et al., 1993).

Table 1. Sensory acceptability data for *garri* samples.

Storage period (months)	Appearance				Taste				Texture				General acceptability			
	Control	**RMT**	**MRT**	**MRB**	**Control**	**RMT**	**MRT**	**MRB**	**Control**	**RMT**	**MRT**	**MRB**	**Control**	**RMT**	**MRT**	**MRB**
0	3.1^{e}	5.4^{b}	2.3^{gh}	4.8^{c}	3.9^{ghi}	4.8^{bc}	3.7^{ghi}	3.3^{iJ}	4.5^{bcd}	4.8^{b}	4.0^{e}	3.2^{f}	3.8^{ef}	5.1^{b}	3.5^{fg}	3.4^{gh}
1		5.6^{ab}	3.0^{f}	4.4^{cd}		5.5^{a}	3.7^{ghi}	4.2^{def}		5.5^{a}	4.2^{cde}	4.2^{cde}		5.6^{a}	3.5^{fg}	4.3^{gh}
2		5.9^{a}	2.4^{g}	3.5^{e}		5.0^{b}	3.2^{ijk}	4.0^{efg}		5.4^{a}	3.0^{fg}	4.2^{cde}		5.5^{ab}	3.1^{ghi}	4.0^{ced}
3		5.4^{b}	2.0^{gh}	4.5^{cd}		4.3^{de}	2.8^{k}	4.6^{bcd}		4.2^{cde}	3.1^{fg}	4.6^{bc}		4.3^{cd}	2.7^{i}	4.4^{c}

Values followed by the same superscripts in the same column are not significantly different (p<0.05); C (Control) = *Garri* produced by the traditional method; RMT = rehydrating the chips before milling, then tradition fermentation; MRT = milling the chips before rehydration, then traditional fermentation; MRB = milling the chips before rehydration, then backslopping fermentation.

The cyanide content of *garri* produced by RMT decreased by 33.43%, MRT by 32.65% while *garri* produced by milling the chips before rehydration and fermentation by backslopping (MRB) decreased by 43.57% over the 3 months of chip storage. These results are lower than the 52 to 63% reduction (Kemdirim et al., 1995; Obilie et al., 2004) and is by far less than the 90 to 93% of Agbor-Egbe and Mbome (2006) and would be attributed to the lower linamarase activity of cassava chips.

MRT *garri* consistently had the highest cyanide content followed by RMT *garri*. The highest values recorded for MRT possibly resulted from the very low pH achieved during fermentation. pH values less than 5.50 stabilize cyanogens against decomposition into HCN (b.p. = 25.7℃) which is easily lost during dewatering and roasting (Westby, 2002). Or it may be due to a larger particle size, which, according to Bradbury and Denton (2010) inhibits cyanide loss. RMT *garri* had the lowest cyanide content during the first month while MRB *garri* had the lowest values during the second and third months. The lowest cyanide content of RMT *garri*, may be due to loss of HCN produced by residual linamarase activity which is primarily responsible for linamarin hydrolysis (Vasconcelos et al., 1990), By the second and third months, linamarase activity and fermentation microorganisms became more susceptible to pH and cyanide inhibition leading to higher HCN content compared to MRB samples. In addition, the prolonged drying of the fermented cassava mash under the sun (mean daily temperature = 31±2℃) may have contributed to the lowest cyanide contents in MRB samples during the second and third months.

All the *garri* samples had cyanide contents above the safe levels of 10 mg/kg (FAO/WHO, 1991) and could be attributed to the method used for cyanide estimation, or to low residual linamarase activity especially since the chip mash was not seeded with fresh cassava mash (FIIRO, 2004) or a preferment (Owuamanam et al., 2011) before fermentation.

Sensory evaluation

Sensory acceptability data (Table 1) showed that chip storage for 1 month generally produced best quality *garri,* the quality decreased progressively as the chips were stored for up to 3 months. In terms of appearance, RMT was most acceptable and was at its peak at the second month while MRT was least accepted and was lowest at month 3. For taste, RMT had the best taste at month 1 while MRT had the poorest taste at month 3. The texture of RMT was the best at 1 month while MRT had the poorest texture at 3 months. A total assessment of the samples showed that RMT was most accepted on months 1 and 2 while MRT had the least acceptance at month 3.

The RMT method yielded *garri* that were most accepted within the first 2 months of chip storage on the basis of appearance, taste and texture. This was followed by MRB which yielded the best quality garri after chip storage for 3 months. The improved appearance of RMT *garri* may be due to reduced browning resulting from the dissipation of heat generated during milling by water used in rehydration. By the third month, *garri* produced by the MRB method was the overall best based primarily on the taste and texture and secondarily, on the appearance. The taste effect may be due to enhanced production (Owuamanam et al., 2011) and retention of the desired organic acids and aroma precursors. The results suggest that sun drying may conserve and contribute to the properties responsible for sensory acceptance of *garri*.

Conclusion

Garri of acceptable sensory qualities and pH was produced from stored cassava chips, but the *garri* quality decreased as chip storage increased to 3 months. Rehydration before milling and traditional fermentation (RMT) gave the most accepted *garri* within the first two months on the basis of general acceptability, appearance, taste and texture. It had the lowest cyanide content within the first month of chip storage and intermediate values thereafter; its pH values were the highest. MRB *garri* were next in sensory and chemical quality within the first two months and was sensorially the best at the third month. It may have the added advantage that sun-drying may conserve nutrients and the compounds necessary for sensory acceptance of *garri* produced from chips stored for 3 months.

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