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Effects of Leaching Cassava Mash in Water on the Glycemic Index of *Garri*

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Abstract

Garri is a fine, fermented and roasted coarse, granular flour of varying texture produced from cassava (*Manihot esculenta* Crantz) tubers. Starch and fibre are the major components of carbohydrate contained in *garri* with low protein content and some essential vitamins[3].The high fibre content of *garri* which is mostly insoluble fibre makes it very filling, and good in reducing the likelihood of bowel diseases. The *glycemic* index (GI) is a numerical measure of how much each gram of available carbohydrate in a food raises a person's circulating blood glucose level after one or two hours of consumption. The need for increasing food choices of the diabetics necessitated this study on the effect of leaching cassava mash in water on the GI of *garri.* The experimental design was adopted using two cassava varieties: a local variety known as *Nwaocha* 'Land Raise' and an improved variety TMS 30575.Each cassava variety used was processed into eight samples and the volume of water (VOW) used for leaching was graded into four levels and samples coded based on the treatment thus: 10.0 liters ($F_{48}L_{10.00}$), 5.0 liters ($F_{48}L_{5.00}$), 2.50 liters ($F_{48}L_{2.50}$) and 1.25 liters ($F_{48}L_{1.25}$) for local and improved varieties. Seven normoglycemic adult volunteers with body mass index (BMI) ranging from 19 to 24 were used to determine the GI of the food samples. Data generated were subjected to one-way analysis of variance (ANOVA) and students 't-test procedure of statistical assessment was used to check for differences of treatment in the cassava varieties. Mean values were further separated using fisher's least significant difference (LSD) and significant was accepted at P<0.05. The result shows that the leaching treatment had significant effect on the GI of the leached *garri* samples was observed in the sample treated with the highest volume of water (VOW) $F_{48}L_{10.00}$(43.08±10.61 & 39.31±5.85) for LV and IV, respectively. The result further shows that the GI of both varieties was not significantly different (P< 0.05) but the local variety had apparent higher GI than the improved variety. Leaching of cassava mash in water significantly reduced the components of starch and sugar (carbohydrate) and subsequent increase in the fibrous material left in the mash and led to the production of low GI *garri* and fermentation further reduced the *garri* GI. It is therefore recommended that *garri* should be leached and the fermentation period prolonged to reduce the GI of *garri* for the purpose of consumption by target groups such as the diabetics.

Background of the Study

Garri is a fine fermented and roasted coarse granular flour of varying texture produced from cassava (*Manihot esculenta Crantz*) tubers. *Garri* as defined by Asegbeloyin & Onyimonyi (2007) is a dry granular food produced from cassava roots through series of processing steps. Afolabi (2009) defined it as a fermented and roasted granular product produced from cassava. Uvere, Peter & Nwogu (2011) defined *garri* as a creamy white starchy pre-cooked grit produced by fermentation of peeled, washed and mashed cassava roots, dehydrated, sieved and roasted. It is a cheap and good source of vigorous energy. The cheapness of this product and ease of preparation has tens its tremendous popularity amongst the city dwellers both in Nigeria and other West African countries (Irtwange & Achimba, 2009). *Garri*seems to be a food of choice even in the face of other food options in urban area (Maziya-Dizon, 2004). It is known to have found its way to famous communities in the United States and Europe (Dipeolu, Adebayo, Ayinde, Oyewole, Sanni, Pearce, Wandschnedier, White & Westby, 2001).

Starch and fibre are the major component of carbohydrate contained in *garri* with low protein content and some essential vitamins (Taiwo, 2006). The high fibre content of *garri* which is mostly insoluble fibre makes it very filling, and good in reducing the likelihood of bowel diseases. According to Sanni & Olubamiwa (2004); Irtwange & Achimba, (2009), in Nigeria, over 70% of cassava harvest is processed into *garri.*

The ability to store *garri* well and its acceptance as a convenience food are responsible for its popularity (Uvere, Peter & Nwogu 2011). Soaked in cold water, it is an excellent snack cherished by children and adults alike on a very hot day. It could be consumed along with sugar, coconut, roasted groundnuts, dry fish, or boiled cowpea. It could be cooked in hot water to make dough-like meal called *eba,* which is traditionally consumed with various soups. The high carbohydrate density of *garri* makes it unacceptable to people who want to lose weight, the diabetic and those with cardiovascular diseases because the amount and type of carbohydrate in food affect blood glucose levels. The consumption of foods exhibiting a high GI is associated with the development of diseases such as type 2 diabetes (Augustine, Franceschi, Jenkins, Kendall & La Vecchia, 2002) and to an increased risk of cardiovascular diseases and obesity (Roberts 2000). Consumption of low GI foods plays a positive role in the treatment of these diseases (Ludwig, 2002).

The glycemic index (GI) is a measure of the effects of carbohydrates in food on blood sugar levels. It estimates how much each gram of available carbohydrate (total carbohydrate minus dietary fibre) in a food raises a person's blood glucose level after consumption of food, relative to consumption of glucose. The presence of fat or soluble dietary fibre can slow the gastric emptying rate, thus lowering the GI. The processing of garri with sour taste involves fermentation which is known to be important not only to enhance detoxification, also improve the quality and hygienic safety of garr i Ogunsua, 1980). Fermentation is an important processing step in garri production by which cyanogenic glucosides in garri are reduced. It precipitates the production of volatile compounds that give garri its unique flavour (Irtwange & Achimba, 2009). Fermentation detoxifies the toxic cyanogenic glucosides (Linamarin & Lotoustralin) which on hydrolysis produces glucose, toxic hydrogen cyanide (HCN) and acetone or propone. Remarkable improvement in protein content of garri was achieved by the use of pure cultures of microorganisms involved in the natural fermentation for solid state cassava mash (Ahaotu, Ogueke, Owuamanam, Ahaotu, & Nwosu, 2011). It appears that a desirable pH is quickly reached when a combined starter culture is used, and this is necessary in order to obtain good sensory properties (Mugulaet al., 2002). Fermentation duration is reduced by seeding the freshly grated mash with previously fermented liquor as a starter, provided that it is mixed thoroughly.

It is postulated that processing *garri* by leaching the loose starch will affect its GI values positively because Starch is a mixture of two glucans; *amylose* and *amylopectin* which are hydrolyzed in aqueous solution. In tubers, starch granules occur free, deposited in cell vacuoles; hence their isolation is relatively simple. When the plant material is disintegrated, the starch granules are washed out with water and sediment from the starch milk suspension is dried (Belitz et al., 2004). According Okeke & Ibeanu, (2011) food systems are the natural loci for developing an integrated strategy for addressing hunger, ill-health and poverty to assure nutrition security. The availability and access to sufficient, safe and nutritious food to meet the dietary needs and food preferences of an individual for active and healthy life is centered on food technology which deals with food production, method of processing and preservation to minimize postharvest losses, and increase availability, safety, quality and preference.

Considering the importance of cassava products in Nigerian diet, there is dearth of knowledge of techniques of producing *garri* with low digestible starch to improve level of resistant starch and dietary fibre. This will eventually increase food availability and preferences to assist people formulate rational dietary and therapeutic diet for diabetic patients and others with clinical conditions necessitating carbohydrate restriction. Dietary fibre is the resistant, undigested and unabsorbed carbohydrate in the diet which is rather fermented in large intestine (Buttriss, & Stokes, 2008). Soluble fibres lower serum lipids, whereas insoluble fibres increase stool weight (Czuchajowska, Sievert, & Pomeranz, 1991). The reason some carbohydrates lower the GI is because they contain more soluble fibre, which slows the release of glucose into the blood stream. Soluble fibre satisfies hunger and lowers cholesterol levels. They have a similar effect on how much fat the body stores unlike foods that have high GI which cause a greater amount of fat to be stored (Brand-miller, Jemie, Foaster-powell & Kaye, 2005). Chelule, Mokoena and Gqaleni (2011) reported that the key challenge to food industry is the production of consumer-friendly foods which contain enough resistant starch for significant improvement in public health. This study therefore applied leaching as a processing technique to reduce the digestible starch and sugar in cassava mash in *garri* production and determined the available the *glycemic* response of the samples on *normoglycemic* adult for possible therapeutic use.

Materials and Methods

The study adopted the experimental design was adopted for the study using two cassava varieties: a local variety known as *Nwaocha* 'Land Raise' and an improved variety; TMS 30575developed by the International Institute of Tropical Agriculture (IITA) were harvested fresh and used for the experiment.

Processing of *Garri* Samples (test food)The cassava tubers were processed into eight (8) different *garri* samples thus;$F_0L_{0.00}$ (unfermented and unleached as a control served as a control for all samples), $F_0L_{1.25}$ (unfermented but leached 1.25 VOW), $F_{24}L_{0.00}$(fermented for 24h but unleached), $F_{48}L_{0.00}$ (fermented for 48h but not leached served), $F_{48}L_{1.25}$(fermented for 48h and leached with 1.25L VOW), $F_{48}L_{2.50}$ (fermented for 48h and leached with 2.50L VOW), $F_{48}L_{5.00}$(fermented for 48h and leached with 5.00L VOW) and $F_{48}L_{10.00}$ (fermented for 48h and leached with 10L VOW) were obtained. Sample $F_{24}L_{0.00}$and $F_{48}L_{0.00}$are indicators of effect of fermenting within 24hours.

Feeding Trial; The method used to select the human (test subjects) subjects for the test was as described by Brand-Miller (2003). Seven (7) adults with very close BMI were selected after screening. Seven non diabetic adult male and female with body mass index ranging from 19kg/m^2 to 24kg/m^2 were selected to determine the *glycemic* index (GI) of the *garri* samples. There was a thorough explanation of the details of the study to the subjects and informed consent obtained in written form. Ethical approval for the study was obtained from the Ethical Committee, Federal Medical Centre, Owerri, Imo State. Five staff of the Department of Home Economics, Alvan Ikoku Federal University of Education, Owerri were selected and trained as research assistants.

Following a 12h fasting, Subjects ate 50 grams available carbohydrate portions of the reference and test foods on different days. Each of the reference food (white bread) was chewed and test foods (*Garri* samples) were soaked in portable drinking water. Each subject was given 250 ml of water to aid digestion on each day of the test. The foods were consumed within 5 minutes and the subjects were asked to remain seated throughout the duration of the test. Finger prick capillary blood samples were taken from subjects using sterile blood lancets. Whole blood glucose concentrations were measured using an automatic glucose analyzer; 'Accu-chek Active' Diabetes Monitoring Kit (Roche Diagnostic, Indiana Polis, USA) before eating the meals (0 minute) and at 15, 30, 45-, 60-, 90- and 120-minute intervals (2h) after consumption of the food. The mean value was calculated as the Incremental area under the curve (IAUC) of the food measured geometrically from the blood glucose concentration-time graph ignoring area beneath the fasting level.

Determination of *Glycemic* Indices

For each person, the incremental area under their two-hour blood glucose response (glucose IAUC) for test food (*garri*) and standard (white bread) were measured. A GI value for the test food (*garri*) was calculated for each person by dividing their IAUC for the test food by their glucose IAUC for the reference food. The test food GI for each subject was averaged to give the mean GI for each test food based on white bread. The final GI value for the test food is the average GI value for the seven volunteer subjects. The Incremental Area Under the Curve (IAUC) for each taste food (*garri)* was expressed as percentage mean IAUC for all the reference food (white bread). The GI of the subject was calculated as:

$$GI = \frac{\text{IAUC of the test food}}{\text{Mean IAUC of standard food}} \times \frac{100}{1}$$

Statistical Analysis

The data obtained from this study were analyzed using conventional one -way analysis of variance (ANOVA) to check the differences in the treatments. Mean values were separated using Fishers' Least Significant Difference (LSD)and student's T-test to check for differences in the cassava varieties (Two samples assuming equal variances) as described by Howell (2007). Statistical Product and Service Solution (SPSS) version 22 (2013) was used as a tool to consider the significance of differences at 5% probability.

Result

Table 1: Total Dietary Fibre (TDF) Content of *Garri* Samples processed from Local and Improved Varieties (g/100g)

Treatment	**Local variety**	**Improved variety**	***P-value (0.05)***	**Remarks**
$F_{48}L_{10.00}$	1.27±0.04^{f}	1.57±0.05^{g}	< 0.001	S
$F_{48}L_{5.00}$	1.77±0.01^{e}	2.11±0.02^{f}	< 0.001	S
$F_{48}L_{2.50}$	1.84±0.01^{d}	2.25±0.00^{e}	< 0.001	S
$F_{48}L_{1.25}$	1.84±0.01^{d}	2.28±0.01^{de}	< 0.001	S
$F_{48}L_{0.00}$	1.85±0.01^{d}	2.29±0.01^{d}	< 0.001	S
$F_{24}L_{0.00}$	2.36±0.01^{b}	2.47±0.03^{b}	< 0.001	S
$F_{0}L_{0.00}$	2.46±0.03^{a}	2.76±0.02^{a}	< 0.001	S
$F_{0}L_{1.25}$	2.17±0.02^{c}	2.35±0.02^{c}	< 0.001	S
LSD	0.0336	0.0371		

Key:

VOW = Volume of water
CAM = Cassava mash
LSD =Least significant difference
$F_{48}L_{10.00}$ = Leached 10L VOW /1kg CAM but fermented 48h
$F_{48}L_{5.00}$ = Leached 5L VOW / 1kg CAM but 48h fermented 48h
$F_{48}L_{2.50}$ = Leached 2.50L VOW / 1kg CAM but 48h fermented 48h
$F_{48}L_{1.25}$ = Leached 1.25L VOW /1kg CAM but 48h fermentation 48h
$F_{48}L_{0.00}$ = Not leached, but fermented 48h
$F_{24}L_{0.00}$ = Not leached but fermentation 48h
$F_{0}L_{0.00}$ = Not leached but not fermented
$F_{0}L_{1.25}$ = Leached 1.25L VOW / not fermented

Table 2: Glycemic Index (GI)of *Garri* Samples from Local and Improved Cassava Varieties Containing 50g available Carbohydrates

Treatment	Local variety	Improve variety	*P-value(0.05)*	Remarks
$F_0L_{0.00}$	69.50 ± 10.96^{b}	61.17 ± 11.14^{b}	0.317	NS
$F_{24}L_{0.00}$	58.22 ± 13.37^{c}	53.13 ± 14.51^{bc}	0.664	NS
$F_0L_{1.25}$	54.80 ± 12.32^{cd}	51.79 ± 21.73^{bc}	0.816	NS
$F_{48}L_{0.00}$	53.70 ± 10.96^{cde}	51.28 ± 22.15^{bc}	0.902	NS
$F_{48}L_{1.25}$	51.54 ± 8.89^{cde}	50.36 ± 22.86^{bc}	0.800	NS
$F_{48}L_{2.50}$	48.41 ± 13.37^{cde}	46.71 ± 14.57^{bc}	0.755	NS
$F_{48}L_{5.00}$	46.50 ± 8.13^{de}	43.47 ± 16.02^{cd}	0.507	NS
$F_{48}L_{10.00}$	43.08 ± 10.61^{e}	39.31 ± 5.85^{d}	0.185	NS
WB	100^{a}	100^{a}		
LSD	11.1	17.2		

Key:

CAM = Cassava mash, NS = Not significant,

WB = white bread (Reference food)

LSD =Least significant difference

$F_{48}L_{10.00}$ = Leached 10L VOW / 1kg CAM, fermented 48h

$F_{48}L_{5.00}$ = Leached 5L VOW / 1kg CAM, fermented 48h

$F_{48}L_{2.50}$ = Leached 2.50L VOW / 1kg CAM, fermented 48h

$F_{48}L_{1.25}$ = Leached 1.25L VOW / 1kg CAM, fermentation 48h

$F_{48}L_{0.00}$ = Not leached, fermented 48h

$F_{24}L_{0.00}$ = Not leached, fermentation 24h

$F_0L_{0.00}$ = Not leached, not fermented

$F_0L_{1.25}$ = Leached 1.25L VOW, not fermented

^{abc}Values with different superscripts in the same column are significantly different ($P < 0.05$).

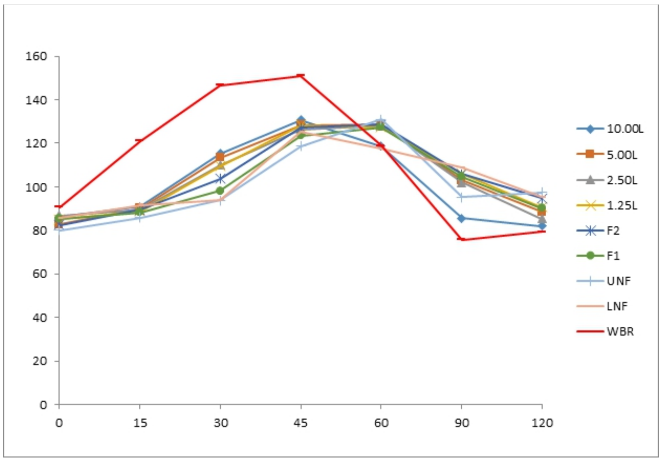

Figure 1: GI Curves from Ingestion of Samples of *Garri* processed from Local Variety of Cassava Tubers

Key:

10.00L ($F_{48}L_{10.00}$)	= Leached 10L VOW / 1kg CAM / 48h fermentation
5.00L ($F_{48}L_{5.00}$)	= Leached 5L VOW / 1kg CAM / 48h fermentation
2.50L ($F_{48}L_{2.50}$)	= Leached 2.50L VOW / 1kg CAM / 48h fermentation
1.25 ($F_{48}L_{1.25}$)	= Leached 1.25L VOW / 1kg CAM / 48h fermentation
F_2($F_{48}L_{0.00}$)	= Not leached / 48h fermentation
F_1 ($F_{24}L_{0.00}$)	= Not leached / 24h fermentation
NNF ($F_0L_{0.00}$)	= Not leached / Not fermented
LNF ($F_0L_{1.25}$)	= Leached 1.25L VOW / Not fermented
WBR	= White bread (Reference food)

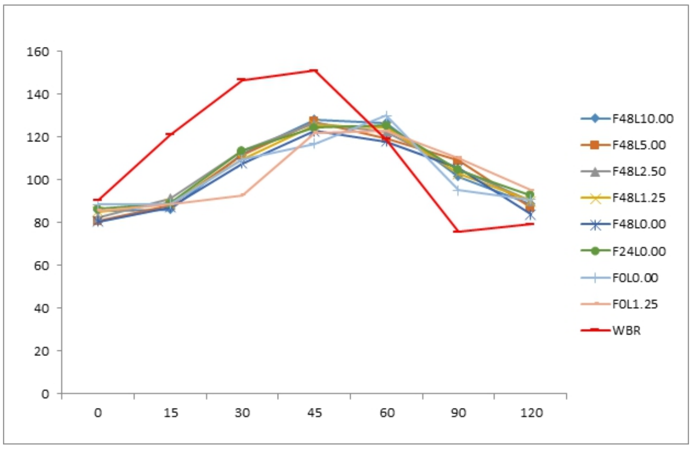

Figure 2: GI Curves from Ingestion of Samples of *Garri* processed from Improved Variety of Cassava Tubers

Key:

F48L10.00L ($F_{48}L_{10.00}$)	= Leached 10L VOW / 1kg CAM / 48h fermentation,
F48L5.00L ($F_{48}L_{5.00}$)	= Leached 5L VOW / 1kg CAM / 48h fermentation
F48L2.50L ($F_{48}L_{2.50}$)	= Leached 2.50L VOW / 1kg CAM / 48h fermentation
F48L1.25 ($F_{48}L_{1.25}$)	= Leached 1.25L VOW / 1kg CAM / 48h fermentation
F48L0.00($F_{48}L_{0.00}$)	= Not leached / 48h fermentation,
F24L0.00($F_{24}L_{0.00}$)	= Not leached / 24h fermentation
F0L0.00 ($F_0L_{0.00}$)	= Not leached / not fermented
F0L1.25, ($F_0L_{1.25}$)	= Leached 1.25L VOW / not fermented
WBR	= White bread (Reference food)

Discussion

The glycemic indices (G1's) of all the *garri* samples obtained in this study from local and improved varieties as stated in table 1 shows that GI of *Garr* samples is not statistically affected by the variety of cassava used for processing provided the same processing techniques are employed. However, the *garri* processed from local variety (LV) had apparent higher (43.08±10.61)GI than those form the improved variety (IV)(39.31±5.85) at the same leaching level. That notwithstanding, for the leaching levels, the G1 of the *garri* samples fell within the same classification (intermediate, medium or low G1). This might not be unconnected to their total dietary fibres (TDF). The TDF of the *garri* in table 1 were statically equal despite the apparent higher value recorded for the IV. Soluble dietary fibres (SDF) principally have effects on glucose and lipid absorption from the small intestine while the insoluble dietary fibres have more pronounced effects on bowel habits, hence, their combined effect influence the availability of carbohydrate in a diet and thus, altering the blood-glucose-raising potentiality of foods (Brand-Miller, 2005).

The result further showed that the leaching treatment had significant effect on the GI of *garri* as the unleached *garri* samples ($F_0L_{0.00,}$ $F_{24}L_{0.00}$ and$F_{48}L_{0.00}$) had the highest GI for both varieties (LV & IV). The result however showed that among the unleached *garri* samples, sample $F_0L_{0.00}$ that did not receive any treatment had the highest G1 (69.50±10.96 & 61.17±11.14) for local and improved varieties. This was followed by unleached sample $F_{24}L_{0.00}$ with the value of 58.22±13.37 for the local variety and 53.13±13.37 for the improved variety. Unleached sample $F_{48}L_{0.00}$ also followed with the value of 53.70±10.96 for the local variety and 51.28±22.15 for the local variety. It therefore follows that the leaching of cassava mash in water is a major treatment that can result to significant decrease in the speed of digestion and absorption of sugar (glucose) into the blood stream.

Also, the results of this work established the idea that fermentation can also reduce the GI of *garri* processed from cassava which is evident in samples $F_0L_{0.00,}$ $F_{24}L_{0.00}$ &$F_{48}L_{0.00}$. Sample $F_0L_{0.00}$ was neither leached nor fermented and had the highest GI of 69.50±10.96 for the local variety and 61.17±11.14 for the improved variety. The difference between the GI values of samples $F_{24}L_{0.00}$ (58.22±13.37 & 53.13±13.37) of both varieties and sample $F_{48}L_{0.00}$(53.70±10.96 & 51.28±22.15) was due to fermentation duration of 24h for sample $F_{24}L_{0.00}$ and 48h for sample $F_{48}L_{0.00}$respectively. This result disagrees with Ihediohanma (2011) in her work based on human *in vivo* trial on the effect of fermentation period on the GI of *garri* which reported that GI of the *garri* samples increased with increase in length of fermentation because the *garri* processed for 24, 48 and 72 hours had the GI of 62, 67 and 73, respectively. The effect of fermentation was also seen among sample $F_{48}L_{1.25}$&$F_0L_{1.25}$which had the same VOW (1.25L) for leaching but differs in fermentation. While sample $F_{48}L_{1.25}$which was leached and fermented for 48h had the GI values of 51.54±8.89 for the local variety and 50.36±22.86 for the improved variety, sample $F_0L_{1.25}$which was leached at the same VOW (1.25L) but was not fermented had the GI values of 54.80±12.32 for the local variety and 51.79±21.73 for the improved variety. The difference amongst them though not significant exists as a result of treatment of fermentation. All the *garri* obtained from cassava mash fermented for 48 hours had GI values with the classification of low GI foods. This implies that *garri* processed from cassava fermented for 48 hours would be low GI foods (with values lower than 55) and that leaching would further reduce the GI of fermented *garri*. Among the *garri* samples in this study, those leached with 5liters and 10liters VOW had significantly lower GI. the GI curve in figure 1 and 2 shows a slow and steady release of glucose of the leached samples as compared to the reference food (white bread) which peaked above 140mg/dl but felt lower than that of the test food after 45 minutes of ingestion. This implies that leaching may have more significant effect on the GI of *garri* as the VOW used for leaching increases.

Conclusion

Leaching of cassava mash in water for the production of *garri* significantly ($P < 0.05$) reduced its GI depending on the VOW used for the leaching. Fermentation also significantly ($P < 0.05$) reduced the GI of the *garri* samples processed from the cassava mash. Leaching resulted to significant losses in the total dietary fibre (TDF) of both varieties as *Garr* obtained from the unleached and unfermented sample had the highest TDF. This suggests that leaching, as well as fermentation, reduces the TDF of *garri* samples, although, fermentation improved the value of insoluble dietary fibre of the fermented samples. The improved variety (TMS 30575) samples had lower sugar and higher dietary fibre than local variety (*Nwocha* 'Land Raises') samples of the *garri* and these results in lower GI. The lower GI obtained for leached *garri* are suggested to have been as a result of leaching of the components of starch and sugar (carbohydrate) and subsequent increase in the fibrous material left in the mash.

Recommendation

It is therefore recommended that *garri* should be leached in water to reduce the GI of *garri* for the purpose of consumption by target group such as the diabetics.

The fermentation period of the mash should be prolonged to reduce the GI of *garri*since there were significant difference ($P < 0.05$) between the GI of fermented samples and the unfermented samples. Preferment liquor should be used to seed fermentation in the leached cassava mash to obtain *garri* with desirable organoleptic qualities. The improved variety is recommended over the local variety to produce *garri* of low GI. *Garri* should be consumed with a soup/stew rich in protein, dietary fibre and B-vitamins to replace those lost during leaching.

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