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Improvement of garri quality by the inoculation of microorganisms into cassava mash

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Abstract

Lactobacillus delbruckii, *Lactobacillus coryneformis*, and a *Saccharomyces* sp., previously found among 214 isolates to be the highest producers of linamarase, amylase, and lysine were inoculated separately or mixed into cassava mash and fermented with, or without dewatering, for 24, 48, 72, 96 and 120 h. At the end of the fermentation period, the mash was converted to garri by heating over a gas burner. The mash and the garri resulting from it were assessed for lysine and residual cyanide, while the garri was also studied for its organoleptic properties. The inoculation of the microorganisms into cassava mash produced a sharp drop in the cyanide content of the mash, particularly when the mixture of organisms was inoculated into undewatered cassava mash rather the single organisms. After 24 h, while the cyanide content of the control (uninoculated mash) mash was 3.06 μg/g in the dewatered mash, and 4.24 μg/g in the undewatered mash, the inoculation of a mixture of the three organisms caused the cyanide content in the inoculated mashes to drop by 150% to 1.96 μg/g (dewatered mash) and by 300% to 1.43 μg/g (undewatered mash). It also appears that the process of producing the garri from the mash by heating, caused a further reduction of the cyanide content: thus the garri always contained less cyanide than the mash from which it was made. The lysine content of the mash was also highest when all three organisms were mixed; it also tended to increase with increasing length of fermentation of the mash. Whereas the single organism most effective in reducing the cyanide content of mash was *Lactobacillus delbruckii*, in the case of lysine production, it was the yeast. The organoleptic properties of the garri which were assessed were flavour, texture, colour and general acceptability. In general these properties were superior at the $P < 0.01$ level in garri made from the undewatered mash in comparison with that from dewatered mash, especially when the mixture of organisms was used. The inoculation of the mixture of the three organisms produced a dramatic reduction in the time (24 h) taken for the highest 'general acceptability' score to be given by the tasters when compared with the singly inoculated organisms and the control, which attained this characteristic after about 96 h of incubation in mash. Published by Elsevier Science B.V.

Keywords: Cassava; Cyanide; Lysine; Microbial inoculation; Garri; Organoleptic properties

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1. Introduction

Cassava, the enlarged root of *Manihot esculenta* Crantz, is an important staple food for about 80 million of Nigeria's estimated population of 100 million, especially those living in the southern parts (Okafor and Ejiofor, 1990). It has important agronomic advantages such as high yields in poor soils, resistance to drought and diseases, storabilty in the soil after maturity, and a comparatively high yield of starch, in comparison with other starchy sources such as potatoes (Cooke and Coursey, 1981).

However it has two important deficiencies. The first is that many varieties contain the toxic cyanogenic glycosides, linamarin and (to a lesser extent) lotaustralin, which have fatal consequences when consumed in unprocessed foods (Conn, 1973). Even when cassava foods are processed, small quantities of the glucosides are often left and these give rise to ailments such as goitre when the foods containing these traces are consumed continuously in diets low in protein (Ekpechi, 1973). The second deficiency of cassava is that it is very poor in protein, containing only about 1% (Cooke and Coursey, 1981).

Cassava may be processed by boiling, roasting, drying, or by fermentation, depending on the variety (Holleman and Atten, 1956). The most popular processing method however, especially for the varieties which are high in the cyanogenic glucosides, is by fermentation. One of the most popular fermented foods derived from cassava is garri, which is eaten by nearly 200 million people across West Africa (Okafor and Ejiofor, 1990). Garri is prepared by fermenting mash produced from cassava by grating, and thereafter heating the fermented mash. During the grating of the root, the endogenous linamarase in the root is released; it makes contact with the linamarin which is consequently broken down. However, the endogenous linamarase is not sufficient to break down all the glucoside in the root and traces are usually carried into the garri (Okafor, 1977). These traces have been implicated in causing diseases such as goitre and tropical ataxic neuropathy when cassava foods are consumed for prolonged periods in conditions of low protein diets (Osuntokun, 1973).

It is now fairly well accepted that the flavour of garri is produced by the fermentative activities of lactic acid bacteria and yeasts, many of which have also been found to produce linamarase (Ngaba and Lee, 1979; Okafor and Uzuegbu, 1987; Okafor and Ejiofor, 1990). These organisms are assumed to subsist on the small amounts of free sugars present in cassava roots. It is presumed that they will grow faster and produce more of the components which flavour the foods more rapidly, when the quantity of sugars in the cassava mash is increased through their own amylolytic activities.

Many organisms are known to secrete amino acids, including lysine which is usually in short supply in starchy substances such as maize and cassava (Okafor, 1987). Should an organism inoculated into cassava mash be able to secrete lysine or any other amino acid into the mash, the amino acid would contribute to improving the nutritional quality of the resulting garri. In a previous publication, three organisms, *Lactobacillus delbruckii*, *Lactobacillus coryneformis*, and a *Saccharomyces* sp., were found to be the highest producers of linamarase, lysine, and amylase among 214 isolates (Okafor et al., 1997).

Traditionally, when cassava mash is fermented for garri production, it is squeezed free of liquid — or dewatered through placing heavy objects on the cloth bags into which the mash is put. However, previous work (Okafor and Ejiofor, 1990) showed that fermentation is more rapid and linamarin (cyanide) removal more effective when liquid is not squeezed out of the mash, i.e., if it is undewatered.

The purpose of this work is to inoculate the three above-named organisms, singly, and mixed, into cassava mash, dewatered or undewatered, and ferment for up to 120 h to study the cyanide and lysine contents of the mash and the garri resulting from it, as well as the organoleptic properties of the garri.

2. Materials and methods

2.1. Organisms used

The methods of isolation, the properties, the methods for the assay of linamarase, lysine, and amylase secreted by these organisms, and the identification of the organisms used in this work, namely, *Lactobacillus delbruckii*, *Lactobacillus coryneformis*,

and *Saccharomyces* sp., have been described elsewhere (Okafor et al., 1997).

2.2. Preparation and inoculation of the cassava mash

Mature cassava roots of the variety TMS 30572 were obtained from the National Root Crops Research Station at Ugwuoba, Enugu State. They were washed in a mixture of 1% mercuric chloride in 70% alcohol, peeled with flame sterilized knives and grated on an autoclave-sterilized hand grater.

For the inoculation of the mash a loopful was scrapped from a 24-h agar slant culture (Okafor et al., 1997) of the relevant organism and shaken in sterile saline and diluted to yield an optical density equivalent to 7.0×10^7 cfu in 3 ml. This was mixed with 1 kg of the mash in a 4-l alcohol-flamed beaker and thoroughly mixed using a flame-sterilized spatula. Where all three organisms were mixed, 1 ml of the broth of each of the organism (total of 3 ml) was mixed and stirred into 1 kg of cassava mash. The inoculated mash, whether de-watered or undewatered was fermented for 24, 48, 72, 96, and 120 h at an ambient temperature. When the mash was to be dewatered, 1 kg of the wet mash wash was placed in a previously washed and autoclaved cotton cloth bag 34 cm $\times$ 18 cm, tied, and placed on a girdle over a sink to permit fluid to drain out. A 3-kg weight was placed on a sheet of glass placed over the bag. In the case of undewatered mash, 1 kg of wet mash was placed in a sterile 4-l beaker and covered with a sheet of glass. For control, one batch each of mash prepared for dewatered and undewatered fermentation was not inoculated with the organisms. The experiment was done twice and the readings were in triplicate.

2.3. Preparation of garri

At the end of the fermentation period, the mash samples were squeezed dry mechanically so that they started with approximately equal moisture contents. They were fried with constant stirring, in a flat pot over a gas fire such that the heat in the mash never exceeded 90°C. Frying was continued for 20 min in each case.

2.4. Assay of the linamarin (cyanide) and lysine contents of the cassava mash and the garri prepared from it

A 5-g amount of the mash or garri was mixed with 25 ml of distilled water and centrifuged at 5000 rpm for 30 min. The supernatant was assessed for linamarin and lysine as already described (Okafor et al., 1997). With regard to the assay of linamarin, it should be pointed out that the glucoside breaks down to acetone, cyanide and water (Conn, 1973). Linamarin is usually assayed by the cyanide released, and it is customary to use cyanide interchangeably with linamarin. This is the case in this paper.

2.5. Assessment of the organoleptic properties of garri inoculated with the microorganisms

The organoleptic properties of the garri samples studied were assessed by twenty female student tasters who were all accustomed to consuming garri, using the nine-point Hedonic sampling and scale. The results and statistically analyzed using Duncan's multiple range test (Duncan, 1955).

3. Results and discussion

Table 1 shows the change of cyanide content of undewatered and dewatered mash and the garri made from them after various periods of incubation of the mash with *Lactobacillus coryneformis*, *Lactobacillus delbruckii*, the *Saccharomyces* sp., individually, and as a mixture of all three. From the table, it can be seen that after 24 h the control in both cases contained comparatively high levels of cyanide (4.24 μg/g in undewatered, and 3.06 μg/g in dewatered mash) whereas in the mash inoculated with all three organisms the cyanide contents had dropped by about 300% to 1.43 μg/g in the undewatered mash, and by about 150% to 1.96 μg/g in the dewatered mash. The combination of all three organisms was, in general, more effective than any of the three organisms acting alone, particularly in the undewatered mash. Of the three organisms, *Lactobacillus delbruckii* was the most effective, acting alone, in reducing the quantity of cyanide in the mash. In the

Table 1
Cyanide[a] content (μg/g) of undewatered and dewatered cassava mash and garri made from it following fermentation with each of three organisms and a mixture of the three organisms after various periods of fermentation

Organisms	24 h		48 h		72 h		96 h		120 h	
	Mash	Garri	Mash	Garri	Mash	Garri	Mash	Garri	Mash	Garri
Undewatered										
Lactobacillus coryneformis (1)	2.94[b]±0.95	2.40±0.35	0.93±0.45	0.40±0.83	0.50±0.92	0.35±0.18	0.57±0.73	0.31±0.08	0.57±0.05	0.28±0.08
Lactobacillus delbruckii (2)	1.86±0.30	0.3±0.09	0.55±0.90	0.29±0.31	0.46±0.04	0.23±0.06	0.43±0.04	0.22±0.11	0.43±0.60	0.20±0.07
Saccharomyces sp. (3)	2.56±1.21	0.26±0.44	1.62±0.98	0.42±0.44	0.57±0.67	0.20±0.23	0.50±0.86	0.23±0.04	0.50±0.43	0.26±0.32
1 + 2 + 3	1.43±0.12	0.54±0.35	0.51±0.04	0.21±0.66	0.42±0.66	0.20±0.38	0.35±0.14	0.19±0.15	0.35±0.82	0.13±0.05
Control	4.24±0.81	3.1±0.34	1.87±0.16	0.55±0.91	0.79±0.21	0.50±0.63	0.63±0.32	0.48±0.33	0.63±0.08	0.46±0.41
Dewatered										
Lactobacillus coryneformis (1)	2.34±0.95	0.53±0.08	0.90±0.98	0.50±0.04	0.62±0.63	0.33±0.04	0.33±0.58	0.31±0.74	0.33±0.67	0.30±0.09
Lactobacillus delbruckii (2)	1.91±0.41	0.51±0.21	0.59±0.08	0.25±0.07	0.41±0.08	0.22±0.38	0.26±0.64	0.21±0.77	0.26±0.66	0.20±0.30
Saccharomyces sp. (3)	2.96±0.52	0.46±0.33	1.60±0.85	0.40±0.80	0.49±0.93	0.23±0.12	0.32±0.34	0.22±0.63	0.32±0.15	0.22±0.95
1 + 2 + 3	1.96±0.98	0.30±0.64	0.65±0.13	0.29±0.31	0.54±0.66	0.22±0.03	0.24±0.11	0.17±0.06	0.24±0.08	0.15±0.11
Control	3.06±0.81	3.10±0.64	1.33±0.14	1.28±0.42	0.68±0.09	1.24±0.91	0.64±0.08	0.47±0.81	0.64±0.19	0.40±0.19

[a] Cyanide content of the unfermented mash at the start of the experiment (0 h) was 5.26±0.12 μg/g.
[b] Figures are means of three readings of each experiment performed twice.

undewatered mash, the mixture of the three organisms was more effective than *Lactobacillus delbruckii*; however, in the dewatered mash *Lactobacillus delbruckii* was as effective as the mixture of all three.

The cyanide content of the garri was always lower than the mash from which it was prepared. The preparation of garri from mash entails heating the mash, and this would suggest that some of the cyanide in the mash was lost during heating; between 30% and 50% of the cyanide in the mash was lost during garri preparation (Table 1). In the uninoculated (control) garri, the cyanide content were 3.1 μg/g from both dewatered and undewatered mash after 24 h. At the end of the experiment (120 h) the figure had dropped to about 0.40 μg/g. For the mixed culture garri the cyanide contents were 0.30 μg/g (dewatered) and 0.54 μg/g (undewatered) at 24 h; at 120 h the corresponding cyanide figures were about 0.15 μg/g. An examination of the figures in Table 1 shows that the mixture was generally more effective than any of the components acting alone, in reducing the cyanide content of the mash and hence of the garri.

The quantities of lysine in the undewatered and dewatered mash after inoculation and fermentation for different periods, as well as in the garri prepared from the mashes, are given in Table 2.

The *Saccharomyces* sp. appears to be the highest producer, acting alone, of lysine in comparison with the other two inoculated organisms. It appeared to produce as much lysine as the mixture of the three in the dewatered mash. In the undewatered mash, especially from the 48 h sample, the mixture outstripped the individual organisms by about 100%. The lysine content in most cases appeared to be reduced slightly during the process of converting mash to garri.

It would appear that the organisms definitely played some role in increasing the lysine content of the mash and the garri, because the lysine in the control (uninoculated) mash was consistently lower than in the mash inoculated with the organisms. Garri produced from the dewatered mash with mixed organisms contained 1.8 and 4.25 g/kg of lysine at 24 and 120 h respectively, the control contained 0.40 and 1.85 for the two periods.

After 24 h of fermentation, the lysine content of

Table 2
Lysine[a] content (g/kg) of undewatered and dewatered cassava mash and garri made from it following fermentation with each of three organisms and a mixture of the three organisms after various periods of fermentation

Organisms	24 h		48 h		72 h		96 h		120 h	
	Mash	Garri	Mash	Garri	Mash	Garri	Mash	Garri	Mash	Garri
Undewatered										
Lactobacillus coryneformis (1)	2.10[b]±0.98	1.95±0.95	2.45±0.21	2.35±0.83	2.45±0.99	2.55±0.61	2.20±0.22	2.35±0.08	2.45±0.04	2.30±0.41
Lactobacillus delbruckii (2)	1.7±0.09	1.35±0.14	3.35±0.34	2.60±0.95	2.40±0.19	2.01±0.03	4.05±0.62	3.90±0.60	3.35±1.00	2.50±0.18
Saccharomyces sp. (3)	2.25±0.73	1.35±0.51	2.30±0.03	2.11±0.92	2.05±1.01	2.65±0.51	2.35±0.04	2.30±0.12	3.85±0.62	3.30±0.11
1 + 2 + 3	2.10±0.04	1.80±0.14	4.90±0.31	3.50±0.42	4.75±0.21	4.45±0.03	4.25±0.61	4.10±0.54	4.35±0.08	4.25±0.18
Control	1.35±0.12	1.40±0.10	1.25±0.33	1.25±0.12	1.60±0.21	1.65±0.82	1.30±0.61	2.00±0.01	2.00±0.07	1.85±0.16
Dewatered										
Lactobacillus coryneformis (1)	1.45±0.98	1.65±0.58	2.10±0.42	2.45±0.62	2.70±0.56	2.75±0.06	3.60±0.90	3.90±0.73	2.25±1.11	2.14
Lactobacillus delbruckii (2)	2.10±0.90	1.45±0.17	3.50±0.60	3.50±0.31	2.50±1.01	2.65±0.05	3.80±0.78	4.50±0.60	2.20±1.04	3.70±0.02
Saccharomyces sp. (3)	2.00±0.61	1.70±0.93	2.65±0.71	2.35±0.55	2.50±0.74	2.55±0.03	2.25±0.17	4.40±0.73	3.50±0.99	2.45±0.16
1 + 2 + 3	2.05±0.22	1.85±0.08	2.55±0.23	2.15±1.02	3.75±0.14	3.30±0.61	4.55±0.18	4.31±0.04	4.75±0.09	4.62±0.31
Control	1.50±0.31	1.55±0.08	1.45±0.66	1.75±0.54	1.70±0.58	1.65±0.11	1.45±0.38	1.55±0.09	1.95±0.71	1.75±0.08

[a] Lysine content of the garri made from the unfermented mash at the start of the experiment (0 h) was 0.85 g/kg.
[b] Figures are means of three readings of each experiment performed twice.

the garri from the control mash was about 30% of the amount in garri produced from the undewatered and dewatered mash inoculated with the three organisms. At the end of 48 h, a significant increase in lysine production occurred in the garri produced from mash with the mixture of organisms, about 100% more than was produced in the garri from the various single inoculations and about 200% more than in the control.

The organoleptic properties of the garri assessed were flavour, texture, colour and general acceptability. The means of the scores given by the 20 tasters for each of the above organoleptic properties of garri produced from undewatered and dewatered mashes, inoculated separately with each of the three organisms, a mixture of all three, and the control are given in Table 3.

In general the scores for the organoleptic properties appeared to be higher in garri made from the undewatered mash, when compared with dewatered mash and the control (uninoculated) mash. The organoleptic properties of garri appeared to improve with longer periods of incubation of the mash, the highest values being attained around 96 h of incubation. For flavour, the highest rating of 7.47 was recorded by the tasters on garri produced from the mixed inoculants after 96 h. This was significantly different from the other ratings at $P < 0.01$, except those indicated in Table 3. The table also shows that garri which was equally acceptable as that with the highest rating was produced after 48 h by the mixed organisms.

In the case of colour, the highest rating of 8.13 came from garri produced by the mixed organisms after 96 h. It was significantly different from all the other ratings (Table 3). The highest mean texture rating was 7.77 and was given for garri from the undewatered mash. The highest mean general acceptability rating was 7.7 and it was recorded for the mixed inoculant garri after 48 h. It was not significantly different for the score of 7.0 also recorded for the mixed organisms after 24 h. One can therefore say that highly acceptable garri was produced by the mixed organisms after only 24 h fermentation.

In summary, the results of this work show that it is better to leave cassava mash undewatered during garri production. Garri from undewatered when compared with that from dewatered mash, especially when the three organisms were mixed, had less cyanide, more lysine and had a higher general

Table 3
Means of the scores given by 20 tasters for organoleptic properties of garri made after fermentation of dewatered and undewatered cassava mash with *Lactobacillus coryneformis*, *Lactobacillus delbruckii*, a *Saccharomyces* sp. and a mixture of all three for various periods

	24 h		48 h		72 h		96 h		120 h	
	D[a]	U[b]	D	U	D	U	D	U	D	U
Lactobaccilus coryneformis										
Flavour	5.33±0.6[g]	5.77±0.5	5.97±0.3	4.93±0.9	5.03±0.9	5.67±0.8	5.33±0.6	*6.80±0.5*[c]	6.17±0.7	*6.47±0.9*[c]
Texture	4.77±0.9	6.3±1.1	5.8±0.8	4.4±1.0	4.5±0.7	5.7±0.8	4.77±0.9	*7.1±0.4*[d]	*6.77±0.8*[d]	6.5±0.5
Colour	4.83±0.9	5.17±0.7	5.53±0.6	4.53±0.8	*7.4±0.4*[e]	5.67±1.0	4.83±0.9	*7.17±0.3*[e]	*7.03±0.4*[e]	6.73±0.3
General acceptability	4.83±1.2	5.93±0.7	5.83±0.6	4.47±1.2	4.6±1.0	6.2±0.6	4.83±1.2	*6.83±0.2*[f]	6.03±1.1	5.9±0.6
Lactobacillus delbruckii										
Flavour	5.70±0.2	5.67±0.5	5.33±0.6	5.97±1.1	5.5±0.7	6.07±0.6	6.4±0.6	*6.77±0.6*[c]	6.3±0.6	6.33±0.7
Texture	6.3±0.3	5.37±0.5	5.47±0.9	*6.70±0.8*[d]	5.97±0.8	5.63±0.6	6.37±0.6	6.2±0.6	6.6±0.5	*6.87±0.3*[d]
Colour	6.13±0.4	5.67±0.4	5.6±0.7	6.27±0.5	5.57±0.7	5.27±0.6	6.2±0.5	6.9±0.5	6.8±0.4	*7.13±0.3*[e]
General acceptability	5.63±0.6	5.53±1.1	5.5±0.8	*6.6±0.6*[f]	5.83±0.7	5.23±0.9	5.93±0.5	6.17±1.2	5.8±0.7	5.73±0.7
Saccharomyces sp.										
Flavour	5.0±0.7	6.27±0.5	4.83±1.1	5.93±0.9	5.87±0.6	5.9±0.6	6.0±0.5	*6.53±0.6*[c]	6.37±0.4	6.17±0.7
Texture	4.4±0.7	*6.87±0.5*[d]	4.5±0.9	*7.03±0.5*[d]	5.43±0.8	5.27±0.5	*7.20±0.3*[d]	*7.07±0.3*[d]	*7.07±0.4*[d]	*6.73±0.6*[d]
Colour	4.83±0.9	6.9±1.0	4.77±0.2	6.67±0.5	5.57±0.7	5.6±0.7	6.83±0.4	6.83±0.5	6.73±0.4	6.8±0.7
General acceptability	4.83±1.2	6.33±1.0	5.03±0.9	*6.70±0.6*[f]	5.0±0.9	5.07±1.0	*7.13±0.5*[f]	*7.73±0.4*[f]	6.27±0.2	6.20±0.6
Mixture of *Lactobacillus coryneformis*, *Lactobacillus delbruckii*, and *Saccharomyces* sp.										
Flavour	5.47±0.6	6.53±0.3	5.53±0.7	*6.57±0.8*[c]	5.93±0.6	*6.70±0.6*[c]	*7.03±0.4*[c]	*7.47±0.4*[c]*	6.23±0.7	6.03±0.7
Texture	4.4±1.1	*7.0±0.3*[d]	5.43±0.7	*7.20±0.5*[d]	*7.27±0.8*[d]	6.23±0.7	*7.63±0.8*[d]	*7.77±0.3*[d]*	*7.33±0.6*	6.57±0.5
Colour	4.87±0.7	6.8±0.3	6.0±0.5	*7.27±0.4*[e]	6.93±0.3	5.9±0.8	*8.0±0.2*[e]	*8.13±0.2*[e]*	*7.3±0.7*[e]	6.27±0.2
General acceptability	6.23±0.4	*7.0±0.3*[f]	*6.63±0.4*[f]	*7.77±0.3*[f]*	*6.67±0.6*[f]	5.80±1.0	*7.27±0.4*[f]	*7.40±0.4*[f]	6.47±0.6	6.0±0.2
Control (uninoculated)										
Flavour	6.03±0.5	5.73±0.5	5.5±0.3	*6.77±0.6*[c]	5.17±0.6	*6.63±0.4*[c]	6.33±0.6	*7.03±0.7*[c]	5.5±0.7	5.23±0.6
Texture	5.1±1.3	4.93±0.8	5.23±1.1	*6.77±0.4*[d]	*7.27±0.4*[d]	4.6±0.7	*6.87±0.9*[d]	*7.2±0.6*[d]	6.03±0.9	5.87±0.9
Colour	5.63±0.6	4.73±0.7	5.83±0.5	*7.40±0.4*[e]	*7.03±0.4*[e]	4.80±0.9	6.77±0.6	*7.87±0.2*[e]	5.73±0.9	5.5±1.0
General acceptability	6.17±0.8	5.90±0.6	5.60±1.1	6.67±1.0	4.90±0.8	4.9±1.0	6.0±0.8	*7.07±0.3*[f]	4.60±1.1	5.00±0.7

[a] Dewatered cassava mash.
[b] Undewatered cassava mash.
[c] *Highest mean score for flavour.
[c] Figures not significantly from [c]* at $P < 0.01$ level.
[d] * Highest mean score for texture.
[d] Figures not significantly from [d]* at $P < 0.01$ level.
[e] * Highest mean score for colour.
[e] Figures not significantly from [e]* at $P < 0.01$ level.
[f] * Highest mean score for general acceptability.
[f] Figures not significantly from [f]* at $P < 0.01$ level.
[g] Figures are means of three evaluations.

acceptability after 24 h, rather than the 96 h which was the time taken to attain best properties of garri, when single organisms were inoculated. The reason why the undewatered condition proved better than the dewatered is not known, but it may be because the enzymes produced by the organisms were removed by squeezing. Similarly, the superiority of the mixed cultures over single cultures could be due synergistic action among them. It is conceivable that the more active amylase producers hydrolyse cassava starch to sugars and this enabled the organisms to grow faster, and to produce the metabolites which render garri acceptable more quickly.

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