Characterization of the Beninese traditional ogi, a fermented maize slurry: physicochemical and microbiological aspects

Mathurin Coffi Nago\(^1\), Joseph D. Hounhouigan\(^1\), Noël Akissoe\(^1\), Elisabeth Zanou\(^1\) & Christian Mestres\(^2\)*

\(^1\) Faculté des Sciences Agronomiques, Département de Nutrition et Sciences Alimentaires, Université Nationale du Bénin, BP 526, Cotonou, Bénin
\(^2\) CIRAD-CA, Laboratoire de Technologie des Céréales, Maison de la Technologie, Bat 16, 73 rue J.-F. breton, BP 5035, 34032 Montpellier Cedex 1, France

Summary

Sixteen commercial samples of ogi, obtained by using traditional ‘Goun’ methodology, from Cotonou and the surrounding area were characterized and compared with maize raw material. Goun methodology uses floury/friable grains and gives a high yield (84% db) of a very white (\(L^*\) value close to 83) and fine (median particle size about 40 µm) slurry. The yield of Beninese ogi, its final water content (58%) and acidity after 3 days of fermentation were slightly higher than for ogi produced using the Nigerian or Ghanaian technology. About 40% of total proteins were lost during the manufacture of ogi, but the digestibility of the residual proteins increased by 20%. At least 50% of both macro- and micromineral elements were lost, with the exception of Fe and Na, whose contents increased. Pasting properties of Beninese ogis were similar to that of mawè, another fermented slurry from Benin. The dominant microflora involved in Beninese ogi was a mixed population of lactic acid bacteria and yeasts, mainly lactobacilli and Candida. The difference in microflora composition compared with Nigerian ogi is probably due to the specific hot grain steeping procedure of the Beninese ‘Goun’ methodology.

Keywords

Fermentation, maize, slurry, porridge, quality.

Introduction

Maize-based products constitute the major part of the human diet in most African countries. In the southern region of Benin, in particular, more than 95% of the households consume maize foods every day, and the national annual per capita maize consumption has been estimated at 85 kg (Bertholon \textit{et al.}, 1975; CIMMYT, 1991). More than 40 different ways of preparing maize have been recorded in the country, including boiling, baking, granulating and frying (Nago, 1989; Nago, Devautour & Muchnik, 1990). Most of these foods are fermented, deriving from two types of intermediate products, mawè and ogi (Nago, 1989; Hounhouigan \textit{et al.}, 1993a). The latter represents 72% of the total fermented intermediate maize production (Nago & Hounhouigan, 1990). In Cotonou, the largest city of Benin (with more than 10% of the national population), about 50 tons of maize are processed daily into ogi, as compared with 9 tons for mawè. Microenterprises produce 86% of the ogi (Nago & Hounhouigan, 1990; Hounhouigan, 1994). Ogi is not marketed in this state, in contrast to mawè, but rather it is found as ready-to-serve foods in markets or at roadsides. The major dishes derived from ogi include (Nago, 1989, 1992; Hounhouigan, 1994) (1) gels of variable stiffness (12–15% dry-matter concentration) having differ-
different local names (akassa, kankan, lio, agidi, kafa), which represent 81% of ogi use in Cotonou; (2) porridges (koko) with dry-matter concentration ranging from 7% to 10% (7% of ogi use), which are consumed as breakfast meals or weaning foods; and (3) a semisolid gelatinized mass (akpan), which becomes a thirst-quenching beverage by adding water, ice, sugar and milk.

Ogi (or similar products) is produced in many other African countries such as Nigeria (where it is known as ogi or akamu), Togo, Ghana, Congo (poto-poto), South Africa (mahewu) and Kenya (ujji) (Doh, 1970; Muller, 1970; Akinrele, 1970; Banigo & Muller, 1972; Steinkraus et al., 1983; Akingbala et al., 1987; Brauman et al., 1993). The general procedure includes six main steps: grain steeping in water, wet-milling, wet-sieving, decanting and fermentation of the slurry for 1–3 days (Fig. 1). However, some differences exist, particularly in the steeping method (Akinrele, 1970), and three main procedures can be distinguished (Guedegbé, 1986): the cold procedure, in which grain is steeped in cold water for 3 days (steeping liquor is changed every day); the ‘Fon’ method, in which maize grains are steeped in water at 85 °C for 24 h; and the ‘Goun’ procedure, mostly used in Benin, in which grains are cooked in boiling water for about 10 min then steeped at ambient temperature for 12–48 h (Fig. 1). Variations in steeping conditions lead to...
important differences in the fermenting microflora and subsequently in the quality of intermediate and final products (Akinrele, 1970; Obiri-Danso, 1994; Adeyemi & Beckley, 1986).

In contrast to ogi, Beninese mawé has been extensively investigated (Hounhouigan et al., 1993a,b,c,d). Workers in Nigeria and Ghana have reported on the technological aspects of local ogi production and its material and protein balances (Akinrele, 1970; Banigo & Muller, 1972; Adeyemi, 1983; Makinde & Lachance, 1976; Akingbala et al., 1987). Others have investigated the physicochemical and microbiological characteristics of the product and the effects induced by cultivar and processing (Akinrele, 1970; Umoh & Fields, 1981; Akingbala, Rooney & Faubion, 1981a; Adeyemi & Beckley, 1986; Adeyemi et al., 1987).

These results cannot be directly extrapolated to the Beninese ‘Goun’ ogi, owing to the differences in its processing method. Consequently, it is necessary to investigate the Beninese traditional ogi processing for further product quality improvement. The present study was carried out to characterize the procedure and the product in terms of material balance and microbiological and physicochemical properties.

Materials and methods

Commercial ogi samples

Sixteen ogi samples were collected from different commercial producers in Cotonou and its surroundings. Ogi samples were placed in separate sterile bags, put in an ice-box containing ice and brought to the laboratory. Subsamples were immediately taken for microbial culture, pH, titratable acidity and colour measurements. The remainder was packed in bags and stored at 2°C.

Maize

Commercial ogis were prepared with maize lots purchased from markets in the area. According to the producers, maize lots could be arranged in six classes, among which two were identified as the local varieties Gnonli and Gbogboué. Maize samples of these six classes were collected for analysis.

As gnonli, a local white ecotype, is a well known variety in Benin, and because it was recognized as one of the maizes used by ogi producers, it was used in technological experiments for determining material balance. It was provided by the Applied Research in Rural Environment Programme in Lokossa (Benin) from crops harvested in the main growing season (March–July) of 1993. The sample was air-dried at ambient temperature (25–35°C) to less than 15% water content (wet basis) and stored at 4°C until used.

Ogi production

Ogi was prepared from Gnonli grains by a local producer, using the traditional ‘Goun’ process (Fig. 1). Ten kilograms of grains were cleaned, boiled for 10 min, steeped for 1 day, wet-milled and wet-sieved using tap water in the ratio (water–ground product) of 5. After settling for 15 min, the starchy sediment was recovered and allowed to ferment. The process was triplicated.

Chemical analyses

Protein, fat and ash contents were determined using the 46–11A, 30–25 and 08–01 AACC methods respectively (AACC, 1984). Dry-matter content of dried grains was determined using the 44–15A AACC method (AACC, 1984). Predrying in an oven at 70°C and grinding was followed by oven-drying at 130°C for 2 h for wet grains and overtails (bran and germ) (Anonymous, 1976). In the case of ogi and souring water (ogi supernatant), a predrying was performed on a hot plate (at 150°C) for 2 h. Starch content was determined by a polarimetric method after hydrolysis of starch by hydrochloric acid, deproteinization and filtration (Godon & Loisel, 1984). For the measurement of the pH of ogi, 10 g of sample was mixed with 20 mL of distilled water, and the measurement was taken with a Hanna 8417 pH-meter (Hanna Instruments, Limena, Italy). Titratable acidity of ogi (2 g of ogi homogenized with 8 mL of distilled water) was determined by titration with 0.01 N NaOH; phenolphthalein (1% w/v) was used as indicator (1 mL per titration). Results were expressed as mg of lactic acid per g of ogi (dry basis). Mineral contents were deter-
mined using an atomic absorption spectrometer for Ca, K, Na, Mg, Fe, Zn, Mn and Cu (Pinta, 1969) and by colorimetry for phosphorus (Stuffins, 1967). Pepsin digestibility of proteins was determined as described by Mertz et al. (1984). The procedure consists of in vitro digestion by pepsin and titration of indigestible proteins using the Kjeldahl method.

Physical analyses

Thousand-kernel weight was determined on 30-g samples and calculated on a dry basis. Dent kernel percentage was evaluated as the relative ratio of the vitreous endosperm area of 100 kernel cross-sections (Louis-Alexandre et al., 1991).

The colour of the ogi samples was measured with a Minolta CR-210b portable chromometer, using chromaticity coordinates $L^*$, $a^*$, $b^*$ and $\Delta E$ (illuminant D65; Hounhouigan et al., 1993a). The instrument was standardized with a visual white tile ($Y = 94.8$, $x = 0.3150$ and $y = 0.3324$). The particle size was determined as described by Sefa-Dedeh (1989): a 100-g ogi sample was shaken for 30 min through 250, 180, 125, 90 and 45 mm screen sieves, on an Endecotts test sieve shaker (Endecotts, London, UK). A continuous jet of water was sprayed onto the sample. The solid content of the sample on each sieve was determined by drying, and the corresponding percentage of the sample (dry weight basis) was calculated. The solid content of the throughs from the bottom sieve (45 μm) was determined by difference.

The pasting characteristics were measured using a Brabender Pt 100 viscograph (Brabender OHG, Duisburg, Germany). Slurries containing 10.0% (w/v) dry matter were analysed using a 700-cmg sensitivity cartridge. The total weight of slurry in the viscograph bowl was 450 g. The mixture was heated at 1.5 °C min$^{-1}$ from 30 °C up to 92 °C, held at 92 °C for 15 min and then cooled to 50 °C at 15 °C min$^{-1}$. The following parameters were measured: pasting temperature ($T_p$, temperature at which viscosity starts to increase), maximum viscosity during heating ($V_m$), viscosity after 15 min at 92 °C ($V_r$) and viscosity after cooling at 50 °C ($V_c$).

Microbiological analyses

Duplicate subsamples (10 g) from ogi sample were homogenized with 90 mL of sterile peptone–physiological salt solution (5 g of peptone, 8.5 g of NaCl, 1000 mL of distilled water, pH 7.0 ± 0.2) and decimal diluted. All cultures were in pour plates. Total aerobic mesophilic bacteria, lactic acid bacteria, lactobacilli, yeasts and Enterobacteriaceae were enumerated after incubation respectively on Plate Count Agar (PCA), MRS agar (Oxoid CM 361), Rogosa agar (Oxoid CM 627), Yeast Extract Glucose Agar (Oxoid CM 545) with addition of 0.01% sterile oxytetracyclin after autoclaving and Violet Red Bile Glucose Agar (VRBG, Oxoid, CM 485), as described by Hounhouigan et al. (1993a). All media were prepared according to the manufacturer’s directions. Lactic acid bacteria and yeasts were randomly isolated from selected plates, and the isolates were purified by successive subculturing on MRS agar and yeast extract glucose agar respectively as described by Hounhouigan et al. (1993c,d). After microscopic examination, purified cultures were grown on slants of the same specific media and stored at +5 °C before identification. Identification was performed according to Harrigan & McCance (1976) and Hounhouigan et al. (1993c,d), using successively various preliminary tests and then API 50 CHL (for lactic acid bacteria) and ID 32 C (for yeasts) kits obtained from API system SA (La Balme-les-Grottes, Montalieu, Vercieu, France).

Results and discussion

Characterization of commercial maize lots

The physicochemical characteristics of the six classes of commercial maize grains identified by and collected at ogi producers were fairly similar with low thousand-kernel weights, typical of local ecotypes (Table 1). However, two types of grains could be distinguished. The first type, including those recognized as Gnonli by ogi producers, had a very low vitreousness, intermediate dent kernel percentage and fairly high starch content, which are typical characteristics of Gnonli kernels (Nago et al., 1997). The second type, called Gbogboué, according to ogi producers, had low dent kernel percentage and low vitreousness typi-
cal of Gbogbouè kernels. This showed that ogi producers prefer small and floury kernels that are friable (Nago et al., 1997).

Material balance in traditional ogi processing in Benin

Using the ‘Goun’ processing method, ogi yielded between 84% and 86% (db) of Gnonli kernels; overtails represented the major part of dry-matter losses (13–15%), whereas less than 2% were lost within discarded water (overtails and supernatant). Beninese ogi yield was slightly higher than those observed in Ghana (80–82%; Andah & Muller, 1972; Banigo & Muller, 1972) and Nigeria (70–77%; Adewusi et al., 1991) using the cold grain steeping procedure. This difference may be due to a better softening of maize kernels using the ‘Goun’ methodology as we measured a water content of steeped grain at 42% (wb) against 38% in the case of the cold steeping procedure (Akinrele, 1970; Banigo & Muller, 1972). However, these differences may also be linked to variation in maize quality, although these studies were carried out using commercial local maize samples that appeared quite homogeneous. The yield of Beninese traditional ogi was much higher than that of commercial mawè (65–71%; Hounhouigan et al., 1993b), which is obtained after two successive purification processes: grains are roughly ground and dry-sieved (pericarp is discarded); obtained grits are extensively washed and floating particles (germs) discarded.

Chemical characteristics of the Beninese ogi

Commercial ogis collected in Cotonou and its surroundings were all prepared using ‘Goun’ procedure with grain steeping for 12–48 h. Their chemical characteristics were very similar (Table 2), with coefficients of variation between samples lower than 7%, and were very close to those of Gnonli ogi. The moisture content (58%) of Beninese ogi was higher than that of Nigerian and Ghanaian ogis (around 50%; Banigo & Muller, 1972; Sefa-Dedeh, 1989). The protein content of Beninese ogi was about 3% lower than that of raw grains; this represented a loss of protein of 38% in the case of Gnonli ogi. This was in the range of protein losses (22–39%; Andah &

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Gnonli-like</th>
<th>Gbogboué-like</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thousand kernels weight (g, db)</td>
<td>183</td>
<td>182–186</td>
</tr>
<tr>
<td>Dent kernel percentage</td>
<td>23–27</td>
<td>9–15</td>
</tr>
<tr>
<td>Vitreousness (%)</td>
<td>24–26</td>
<td>48–53</td>
</tr>
<tr>
<td>Starch content (%)</td>
<td>77</td>
<td>75</td>
</tr>
<tr>
<td>Protein content (%)</td>
<td>9.8</td>
<td>10.0–10.6</td>
</tr>
<tr>
<td>Lipid content (%)</td>
<td>4.0–4.1</td>
<td>3.9–4.4</td>
</tr>
<tr>
<td>Ash content (%)</td>
<td>1.35–1.38</td>
<td>1.22–1.47</td>
</tr>
</tbody>
</table>

Table 1 Physicochemical characteristics of commercial maize lots used for preparing ogi

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Commercial ogi</th>
<th>Gnondi ogi Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry-matter content (%)</td>
<td>42</td>
<td>40–44</td>
</tr>
<tr>
<td>Starch content (%)</td>
<td>77</td>
<td>76–80</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>7.2</td>
<td>6.7–7.9</td>
</tr>
<tr>
<td>Free lipids (%)</td>
<td>3.6</td>
<td>3.0–3.5</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.5</td>
<td>0.4–0.6</td>
</tr>
<tr>
<td>pH</td>
<td>3.4</td>
<td>3.3–3.7</td>
</tr>
<tr>
<td>Titratable acidity (mg lactic acid g⁻¹, db)</td>
<td>13.8</td>
<td>13.8–16.0</td>
</tr>
<tr>
<td>Pepsin digestibility (% initial protein)</td>
<td>95</td>
<td>ND</td>
</tr>
</tbody>
</table>

*Standard deviation.
ND, not determined.

Table 2 Chemical characteristics of Beninese commercial ogi (16 samples analysed) and of ogi produced from Gnonli

© 1998 Blackwell Science Ltd

Muller, 1972; Banigo & Muller, 1972; Adewusi et al., 1991) obtained for ogi processing using the cold steeping procedure and close to the losses measured in the case of commercial mawè (37%, Hounhouigan et al., 1993b). In addition, ‘Goun’ ogi had lower lipid and ash contents than raw grains (Table 1), indicating that a partial degerming occurred during processing. Degerming was more efficient in the Goun process than using the cold steeping ogi process, which gives ogi with a residual lipid content of 3.9–4.2% (Muller, 1970; Andah & Muller, 1972; Banigo & Muller, 1972). This might be due to the better grain softening observed with the ‘Goun’ procedure, which should facilitate kernel fractionation during processing. Nevertheless, degerming was much less efficient than with the two-step purification procedure of mawè whose residual lipid content was of 1% (db; Hounhouigan et al., 1993a).

Mineral content of the various commercial ogis was quite similar with a coefficient of variation between samples ranging from 3% to 9%. With mean values of 85 and 123 mg 100 g⁻¹ (db), respectively, K and Mg contents of ogi were about one-quarter of that of whole grains of Beninese local ecotypes (Nago et al., 1997). Similarly, mean values for Ca and Zn (5.3 and 1.1 mg 100 g⁻¹, db) and for P, Mn and Cu (123, 0.5 and 0.08 mg 100 g⁻¹, db) were one-third and one-half, respectively, of those of whole grains. On the contrary, ogi Fe and Na contents (3.6 and 2.8 mg 100 g⁻¹, db) were higher than for whole grains. These minerals are likely to arise from water (for Na) and small particles extracted from the grinder (made of iron disc plates).

Beninese ogis (Table 2) were slightly sourer than Nigerian and Ghanaiian ogis, whose pH ranged from 3.5 to 4.5 (Akinrele, 1970; Banigo & Muller, 1972; Umoh & Fields, 1981; Adeyemi et al., 1987; Akingbala et al., 1987). The Beninese ogi titratable acidity was similar to that of commercial Beninese mawè (14 mg g⁻¹ db; Hounhouigan et al., 1993a).

In vitro protein digestibility of ogi was very high (Table 2), and about 20% higher than that of whole kernels of Beninese local ecotypes (Nago et al., 1997). This might be due to the action of proteolytic enzymes either present in the grain (Nche et al., 1996) and/or produced by proteolytic bacteria (Tongnual et al., 1981). This improvement of protein digestibility could partly balance the nutritional loss of proteins during the extraction process.

Physical characteristics of the Beninese ogi

Beninese ogi has a fine texture, with a median particle size around 40 μm (Table 3) and about 80% of particles under 90 μm. Beninese ogi particle size distribution was close to those of commercial mawè (Hounhouigan et al., 1993a) and Ghanaiian ogi (Sefa-Dedeh, 1989).

Beninese ogi had a high luminosity ($L^*$) and a low ΔE (total colour difference with standard white tile), which are good indices of quality as consumers look for whiteness of ogi and derived products (Akingbala et al., 1981b). Beninese ogi

---

**Table 3** Physical characteristics of Beninese commercial ogi (16 samples analysed) and of ogi prepared from Gnonli

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Commercial ogi</th>
<th>Gnloni ogi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD*</td>
<td>Range</td>
</tr>
<tr>
<td>Particle size distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x &lt; 45 μm</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td>x &lt; 90 μm</td>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>x &lt; 125 μm</td>
<td>88</td>
<td>2</td>
</tr>
<tr>
<td>x &lt; 180 μm</td>
<td>91</td>
<td>3</td>
</tr>
<tr>
<td>x &lt; 250 μm</td>
<td>94</td>
<td>3</td>
</tr>
<tr>
<td>Colour parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L^*$</td>
<td>83</td>
<td>0.6</td>
</tr>
<tr>
<td>$a^*$</td>
<td>-1.9</td>
<td>0.3</td>
</tr>
<tr>
<td>$b^*$</td>
<td>9.5</td>
<td>0.6</td>
</tr>
<tr>
<td>ΔE</td>
<td>16.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Standard deviation.*
colour parameters were similar to those of commercial mawè (Hounhouigan et al., 1993a).

**Pasting behaviour of the Beninese ogi**

Brabender viscosity profiles of Beninese traditional ogis were similar to those obtained in previous works for maize or sorghum ogis and for mawè (Banigo et al., 1974; Adeyemi, 1983; Adeyemi et al., 1987; Hounhouigan et al., 1993a). However, we could only compare Beninese ogi pasting parameters with those observed for mawè (Table 4) because no other study on ogi has been made with 10% dry-matter pastes. Great variations were observed in commercial and Gnonli ogi paste viscosities. They were however in the same range and similar to the values observed for 3 days' fermented commercial mawè that had for example a $V_e$ of 983 (Brabender units; Hounhouigan et al., 1993b). Beninese ogi and mawè had also similar pasting temperatures.

**Table 4** Pasting behaviour of Beninese commercial ogi (16 samples analysed) and of ogi prepared from Gnonli measured using the viscoamylograph on 10% (db) slurries

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Commercial ogi Mean</th>
<th>SD*</th>
<th>Gnonli Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_p$ (°C) †</td>
<td>71.6</td>
<td>0.8</td>
<td>71–73</td>
</tr>
<tr>
<td>$V_m$ (BU) ‡</td>
<td>936</td>
<td>94</td>
<td>882–996</td>
</tr>
<tr>
<td>$V_r$ (BU)</td>
<td>542</td>
<td>57</td>
<td>485–620</td>
</tr>
<tr>
<td>$V_e$ (BU)</td>
<td>1002</td>
<td>130</td>
<td>922–1058</td>
</tr>
</tbody>
</table>

*Standard deviation. 
†Pasting temperature. 
‡Brabender unit. 
$V_m$, maximum viscosity during heating; $V_r$, viscosity after 15 min at 92 °C; $V_e$, viscosity after cooling to 50 °C.

A total of 65 strains of lactic acid bacteria were isolated from the product. They were mostly heterofermentative lactobacilli. Three main Lactobacillus species ($L. \text{ fermentum}$, biotype cellulosus, $L. \text{ brevis}$ and $L. \text{ fermentum}$) accounted for 90% of the lactic acid bacteria isolates, whereas $L. \text{ curvatus}$ and $L. \text{ buchneri}$ accounted for 6%. These findings are quite similar to those reported by Hounhouigan et al. (1993d) for mawè, by Adegoke & Babalola (1988) for Nigerian ogi, and by Mbugua (1984) for uji, a spontaneously fermented maize product from Kenya. However, Akinrele (1970) isolated from Nigerian ogi, obtained with the cold steeping procedure, three other bacteria, namely $L. \text{ plantarum}$, Corynebacterium sp. and Aerobacter cloacae, and found the first to be the predominant species. Failure to find $L. \text{ plantarum}$ in this work could be a result of difference in processing and particularly in the steeping procedure. Indeed, steeping duration and temperature can induce dramatic changes in the microbial population of ogi (Akinrele, 1970).

Fifty-four strains of yeasts were isolated from Beninese ogi. Candida species represented 41% of the isolates, including mainly $C. \text{ humicola}$ and $C. \text{ kruisei}$. Geotrichum spp. accounted for 26% of the yeast isolates. Other isolates were identified as Cryptococcus and Trichosporon species. Some of these yeasts were detected in Nigerian ogi (e.g. $C. \text{ kruisei}$, Rhodotorula spp.) by Akinrele (1970) and in mawè (e.g. $C. \text{ kruisei}$, $C. \text{ keyfyr}$) by Hounhouigan et al. (1993c). Other yeasts have been also reported from ogi, namely Saccharomyces cerevisiae and Candida mycoderma (Akinrele, 1970).
Conclusion

Beninese ogi producers use small, floury/friable grains as raw material. Commercial ogi is very similar to that made from Gnonli using the traditional Beninese ‘Goun’ methodology in controlled conditions. In this case, the ogi yield was 84% (db). Beninese ogi, partly degemerized, was a very white, fine and watery mash. It appeared slightly sourer and more watery than Nigerian ogi. This difference might be due to the specific hot steeping procedure used in Benin and/or to the use of floury/friable grains.

The dominant microorganisms involved in the fermentation of Beninese ogi were lactobacilli (mainly L. cellobiosus, L. brevis and L. fermentum) and yeasts (Candida humicola, C. krusei, Geotrichum spp.). Differences in microflora composition compared with Nigerian ogi may due to the hot steeping procedure used in Benin.

Acknowledgements

Facilities and technical assistance were provided by the Dutch-Beninese University Cooperation Programme. The authors are grateful to Mr Gallon (ORSTOM-Montpellier) for support on mineral analyses.

References


