Microorganisms present in the unfermented grains of millet at the initial stage of steeping and after sieving at the initial stage of souring for the preparation of kamu were moulds (Aspergillus versicolor, Penicillium nigricans and Rhizopus stolonifer), bacteria (Pediococcus pentosaceus and Lactobacillus plantarum) and a yeast (Saccharomyces cerevisiae). Only the bacteria and yeast persisted to the end of the steeping period. These, together with another yeast, Candida krusei, brought about the final souring of kamu.

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Fermentation of millet to produce kamu, a Nigerian starch-cake food

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Millet (Pennisetum typhoides) is fermented by the Hausas of northern Nigeria to produce a starch-cake food called kamu, which is also called gasara or kallii by the Hausas. The preparation of kamu is still done traditionally in the homes in the following manner. Millet grains are soaked in cold water for 12 to 24 h. The steep water is drained off, the grains are washed and small quantities of pepper (Capsicum frutescens Linn.), ginger (Zingiber officinale Roscoe) and fruits of Eugenia calophylla Linn. (Hausa name: Kaninfari) are added as spices. The grains and the spices are wet-milled and sieved with water through a fine wire-mesh screen. The pomace that collects on the sieve is discarded; the filtered liquor is allowed to settle for 3 to 6 h to produce a sediment (called kamti), which is recovered by decanting the supernatant liquor. The cream-coloured kamu is usually marketed as a wet cake. Kamu is diluted to 8 to 10% (w/v) total solids in water and boiled into a porridge called koko, which is drunk (with or without sugar) with bean-balls (akara). Although koko is taken during any part of the day, most consumers prefer it as a breakfast and an early evening refreshment.

Starch-cake foods similar to kamu are prepared (without the addition of spices) from maize (Zea mays) and Guinea corn (Sorghum bicolor); these are called ogi and ogi-baba, respectively, by the Yorubas of southern Nigeria. However, the Hausas of northern Nigeria prefer kamu to any other starch-cake food.

Unfermented whole millet grains, which contain about 84% carbohydrate and 9% protein (Oyenuga 1968), are not normally consumed directly, either cooked or uncooked. However, when the pericarps (grain coats) of unfermented grains are removed, and the cotyledons are ground into powder, the powder may be cooked over boiling water (in a steam bath) to produce foods called burubisiko and fura. Kamu is the only fermented product from millet, and it is consumed by more people and throughout a wider area than burubisiko and fura.

Various workers have carried out studies on the fermentations of maize for ogi production and Guinea corn for ogi-baba production in Nigeria (Oke 1967; Akinrele 1970; Au & Fields 1981; Umoh & Fields 1981; Odunfa & Adeyele 1985). No report is yet available on the production of kamu, which differs from the other starch-cake foods by its shorter period of fermentation and addition of spices. The present work provides information on the microbiological changes, as well as the efficacy of the various isolates, during fermentation of millet grains to produce kamu.
Materials and Methods

Preparation of Kamu

Millet grains, purchased from a local market in Ilorin, were picked over by hand to remove all unwanted particles and then used to prepare kamu by the traditional method as follows. The grains (2 kg) were soaked in cold tap water (5 l) for 24 h at room temperature (28 ± 2°C). The steep water was drained off and the grains washed with tap water. Water was drained off from the grains. To the grains were added 8 g pepper (C. frutescens), 20 g ginger (Z. officinale) and 1.5 g fruits of E. calophyloides, wet-milled, and sieved through a fine wire-mesh screen (pore size 0.81 mm²) to remove the pomace, which was discarded. The filtered liquor was allowed to settle for 6 h to produce a sediment (kamti).

Isolation Procedure

Microorganisms were isolated from the steep water and from the supernatant liquor of kamu at zero time and 6 h intervals. The zero time samples were taken immediately the grains were soaked in water and after sieving, for the steeping and souring stages respectively. One ml of each sample was serially diluted with sterile water. The 10⁻¹ dilution was plated for moulds, while 10⁻³ and 10⁻⁴ dilutions were plated for bacteria and yeasts. Isolation media used were yeast extract/tryptone/agar, nutrient agar, plate count agar (PCA) and MRS agar (Odunfa & Adeyele 1985; Oyeyiola 1989) for bacteria and potato/dextrose/agar, malt extract/agar and PCA for fungi. The plates were incubated at 30°C for 72 h for bacteria, and for 5 days for fungi. Half of bacterial plates were incubated under aerobic conditions. The other half were incubated in an anaerobic jar. The anaerobic atmosphere was provided with a BBL ‘Gas Pak’ of H₂/CO₂. Colony counts were made and representative colonies were taken for identification.

Identification of the Isolates

Pure cultures of isolates were obtained by repeated streaking and preserved on agar slants. Morphological examinations and various biochemical tests were carried out on the microorganisms, the results of which enabled their identification following the keys of Buchanan & Gibbons (1974) for bacteria and Perera et al. (1978), Seshachalam et al. (1980), Onions et al. (1981) and Odunfa & Adeyele (1985) for moulds and yeasts.

pH and Titratable Acidity Measurements

The pH of each liquor sample was read with a pH meter. Titratable acidity was determined on 25 ml filtrate of the liquor sample against 0.1 M NaOH using phenolphthalein as indicator. All results of pH and titratable acidity measurements were statistically analyzed using a two-way ANOVA to test for significant differences, with the hours taken as treatments and the replicates taken as blocks.

Inoculation Experiments

Clean, dry millet grains (1 kg) were soaked in 2.5 l of 5% sodium metabisulphite solution (to prevent microbial infection) for 24 h (Akinrele 1970). The grains were then drained and washed in four changes of 5 l sterile tap water. Water was drained off from the grains. Then 4 g pepper (C. frutescens), 10 g ginger (Z. officinale) and 0.8 g fruit (E. calophyloides) were added as spices to the grains; the mixture was wet-milled with water and then sieved as before. The filtered liquor was thoroughly mixed, and 100 ml aliquots were transferred into each of a number of 250 ml conical flasks and sterilized at 115°C for 15 min. The content of each flask was separately inoculated (aseptically) with 2 ml of broth culture of the following species (raised from pure cultures of isolates obtained earlier in this study): Pediococcus pentosaceus, Lactobacillus plantarum, Saccharomyces cerevisiae and Candida

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