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Steeping time and dough fermentation affect the milling behaviour and quality of white *kenkey*(*nsiho*), a sour stiff dumpling prepared from dehulled maize grains

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ABSTRACT

White *Kenley* is a traditional stiff dumpling produced from fermented dehulled maize grains in Ghana. The physico-chemical modifications which occur during combination of various steeping (12, 30 and 48 h) and fermentation (0 h, 12 h and 24 h) times were assessed to study the impact of these unit operations on the quality of white *kenkey*. Water uptake by soaked grains and the release of metabolites were followed during grains steeping and particle size distribution after milling was determined. Steeping time exceeding 24 h was required to produce a fine wet milled flour while water uptake was completed after 8–10 h. This was parallel to hydrolysis of proteins and/or hemicelluloses which occurred after 16 h. Changes in acidity and glucose content were determined in the grain after steeping and in the dough after fermentation. The texture of the kenkey was determined using a texture analyzer. Increases in acidity were higher during dough fermentation than in steeping. Stickiness of the white *kenkey* decreased consistently with steeping time. Principal Component Analysis showed that a combination of long steeping and short fermentation times gives white *kenkey* with low stickiness (and high fineness), low acidic taste and low fermented odour.

1. Introduction

Maize is the most important cereal in Ghana in terms of production and consumption. In 2012 the total maize production was 2 billion metric tons, accounting for 3% of the Agricultural Gross Domestic Product (SRID, 2013). Several traditional food products are made in Ghana from maize including *banku* (a stiff porridge prepared from cooked fermented whole maize dough mixed with fermented cassava dough in a ratio of 2:1), *Koko* (fermented maize porridge), and *aboloo* (dehulled fermented steamed maize dumpling) (Johnson and Halm, 1998), but the most popular product is *kenkey*, a sour stiff dumpling made from fermented maize dough which is wrapped in leaves and boiled (Halm et al., 2004). Most consumers interviewed by Obodai et al. (2014) reported that they eat kenkey more than 2–3 times in a week.

Kenkey is made by steeping maize grains in water for 1–2 days during which the grains start to ferment. The steeped grains are then milled, kneaded into dough and allowed to ferment for 2–4 days. Part of the dough is cooked, mixed with the remaining uncooked dough into a gelatinous paste (aflata), moulded into balls, wrapped in plantain leaves or maize husks and cooked into *kenkey*. *Kenkey* has a pH of about 3.7, moisture level of between 52 and 55% (Halm et al., 2004) and is usually eaten with a pepper sauce and fish. Two main types of *kenkey* are known, Ga and Fante *kenkey* which have originated and are dominant in different parts of the country (Halm et al., 2004). These two types of *kenkey* have received considerable research attention and there is a lot of scientific information on these products in the international literature

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including starter cultures that can be used for their production (Fadahunsi et al., 2012), aroma of *kenkey* (Annan et al., 2003) and use of GMP and HACCP as a quality management system for assuring the safety of *kenkey* (Amoa-Awua et al., 2007). In addition, the milling, steeping and fermentation steps have been extensively studied (Nche et al., 1994, 1996; Nout et al., 1996) and an accelerated process which still retains the steeping step for producing kenkey has been proposed as steeping was found necessary for the production of good quality kenkey.

Apart from Ga- and Fanti-*kenkey* other types of *kenkey* exist, though less known. Such products are however important in some parts of the country. One of such products is *nsiho* or *apkorhie*, and is *kenkey* produced from dehulled or degermed maize grains and is consequently more whitish in colour. Compared to Ga- and Fante-*kenkey*, *nsiho* or white *kenkey* is less sour in taste, hence blander, and less sticky in texture (Obodai et al., 2014). Currently attempts are being made in Ghana to develop white *kenkey* further for a wider market as part of a European Union project known as African Food Tradition Revisited by Research (AFTER). Since steeping and fermentation have been shown to be critical for the quality of *kenkey*, this study focused on assessing the effect of steeping time and duration of dough fermentation on the quality of white *kenkey* with respect to its physiochemical characteristics and texture.

2. Materials and methods

2.1. Raw material

One hundred kg of maize was purchased from the open market for experimental work in the laboratory. It was purchased after preliminary visual assessment to ensure that the maize grains were free from visible mould growth, foreign material and suitably dry. The maize was dehulled in an Engelberg mill (Anglebell Ltd., Doncaster, U.K.). The dehulled grains had a lipid content of 0.47 g/100 g, and an average particle size of 2.8 mm.

2.2. Kenkey processing

Two kg of the dehulled maize grains was washed with water and steeped in water at room temperature (ca 30 °C) for 12, 30 or 48 h. The steeped grains were washed again with 500 ml of water and milled into a meal using a mini disc attrition mill (Rajan Universal, Chennai, India).

One portion of the dehulled maize meal was first made into a slurry by adding water in a ratio of 1:1. The slurry was poured slowly into 500 ml of boiling water in a cooking pan and stirring continuously whilst heating. The mixture was allowed to cook for 5 min into a thick paste, cooled and molded into spherical balls of about 300 g each. Each ball was wrapped in maize husks and steamed for 30 min into white *kenkey* using a steam cooker (HD9120, Philips Viva collection, Dampfgarer, the Netherlands).

The other portion of the dehulled maize meal was kneaded into dough after adding water in a ratio of 1:2 (w/v) and allowed to ferment spontaneously. After 12 h or 24 h of fermentation two-thirds of the dough (200 g) was pre-cooked as previously described and mixed with the remaining 100 g of the uncooked dough. The mixture was molded into balls, wrapped with maize husks and steamed.

Fig. 1 summarizes all the processes and products prepared for analysis; the samples were coded with the steeping time (hours, preceded by “S”) and the fermentation time (hours, preceded by “F”). The experiments were triplicated.

2.3. Kinetics of steeping

Dehulled grains (250 g) were soaked in 350 ml of distilled water at a controlled temperature (35 °C) for 2, 8, 16, 24 or 48 h. Aliquots of steep water was regularly collected to determine lactic acid, ethanol, and free proteins and sugars contents. The steeped grains were collected and drained for excess water. The moisture content of the grains was determined and the grains were milled using a Thermomix Vorwerk mill (Vorwerke, Germany).

2.4. Analytical methods

2.4.1. Determination of moisture content

Moisture content was determined by the oven dry method according to Approved Method 44-19 (AACC, 2000).

2.4.2. pH and titratable acidity

Ten gram of the sample (flour/dough) was dispersed into 20 ml distilled water and homogenized for 2 min. The pH was read after 1 min. 70 ml distilled water was added and the slurry titrated against 0.1 N (freshly prepared) sodium hydroxide under continuous agitation until pH 8.5 was reached. After 5 min, the pH was adjusted to 8.5 and the final amount of sodium hydroxide used read. Titratable acidity was expressed as lactic acid equivalent percentage (wet basis).

2.4.3. Determination of organic acids and free sugars

The glucose, ethanol and lactic acid present in the samples were determined using high performance liquid chromatography according to Mestres and Rouau (1997). The arabinose content of steep water was determined by using high performance ion chromatography using 4 × 250 mm CarboPac MA1 Column (Dionex, Germany) coupled with Pulsed Amperometric Detector (Decade 2, Antec Leyden, the Netherlands). The eluent was degassed 480 mM NaOH solution pumped at a flow rate of 0.4 ml/min. Freshly prepared solutions of arabinose was used to calibrate the system (Hanko and Rohrer, 2013).

2.4.4. Protein determination in steep water

Steep water (0.25 ml) was mixed with 0.25 ml of distilled water and 1.5 ml of Bradford Reagent (B6916, Sigma-Aldrich). The mixture was left to incubate at room temperature for 5 min and the absorbance read at 595 nm. The concentration of soluble proteins in the steep water was calculated using a standard reference curve obtained from Bovine Serum Albumin (Sigma-A9418) between 0 and 1.5 mg/mL.

2.4.5. Colour determination

The colour of fresh meal and maize dough were measured using a colorimeter (CR310 Chromameter, Minolta, Japan) which was calibrated with a white tile ($L = 97.51$, $a = 5.45$, $b = -3.50$) according to AACC method 14–22.01 (2000). The colour was expressed in terms of lightness (L) and colour difference (ΔE). (ΔE) was calculated as $(\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2}$ where L = lightness; a (+) = red a (−) = green; b (+) = yellow, b (−) = blue colour value. The colour of each sample was measured five times.

2.4.6. Wet particle size distribution

Fifty grams of maize dough was sieved using a sieve shaker (Analysette 3Pro, Fritsch, Germany). The sieves were stacked from the coarsest to the finest mesh: 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm and <0.125 mm. The sample was placed on the top sieve and washed down manually using distilled water. The stack was gradually disassembled and each sieve washed with water until no more solid material passed through the sieve. The content of each