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Research Article
Physicochemical and Sensory Evaluation of Maize Cake (*Ipekere*) Produced from Maize (*Zea mays*) Paste

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Abstract
Background and Objectives: Locally fermented and processed foods form the bulk of human diets due to its nutritional composition, ease preparation and affordability to the less affluent individual in a given population. This study was designed to evaluate the physicochemical and sensory properties of maize cake (*ipekere*) produced from maize paste. **Materials and Methods:** The maize samples were washed and wet-milled to form paste for *ipekere* production by frying in palm oil. Isolation of microorganisms was carried out using serial dilution and pour-plate techniques. The pH and total titratable acidity of the fermenting samples were monitored on each day of the fermentation. The sensory parameters of the maize cake (*ipekere*) were assessed. **Results:** The microbial analysis showed an increase in total microbial loads with increase in fermentation time. The bacterial loads increased from 1.5-7.0 CFU mL^{-1} while the fungal loads increased from 1.0-6.2 sfu mL^{-1}, respectively. The highest bacterial and fungal counts 7.0 CFU mL^{-1} and 6.2 sfu mL^{-1} were obtained from fermenting yellow maize hand-grinded and white maize machine-grinded while least counts 1.5 CFU mL^{-1} and 1.0 sfu mL^{-1} were obtained from yellow maize and white maize blended, respectively. Different microorganisms were isolated from the fermented maize. *Lactobacillus fermentum* and *Saccharomyces cerevisiae* form the predominant micro-organisms. The pH of the fermenting samples decreased while total titratable acidity increased. The organoleptic properties of the maize cake (*ipekere*) produced was best rated with respect to aroma, taste and overall acceptability. **Conclusion:** However, the high sensory quality of the *ipekere* produced from fermented maize could enhance its acceptability as food snacks to the consumers.

Key words: Cereals, *ipekere*, maize, fermented foods, sensory parameters

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The flair for consumption of cereals and cereal based fermented food products by the less affluent individual in a population are on increase. Cereals have low protein; it can be fortified with plant based protein food source[1,2]. Prior fermentation, cereal products can be obtained by wet-milling, cooking or frying which can be eaten with palp, custard and soaked-garri [3]. Some of the fermented foods from cereal such as *ogi*, *kunu*, *kati* etc are widely consumed in Nigeria as weaning foods for infants and as dietary staples for adults[4,5].

Fermentation could result in the leaching of essential nutrients into the fermenting medium. Different researchers have reported on how to improve the physical and biochemical nature of a number of traditionally fermented cereal based foods which can be classified based on their form (raw or fermented)[6]. Fermentation helps in improving the starch and protein digestibility, bioavailability of minerals and reduction in the anti-nutrients content[7]. Examples of cereals include maize, sorghum, millet, rice or wheat.

Maize (*Zea mays*) is a cereal based staple food crops grown in Nigeria and other parts of the world. The production rate account for 785 Mt with United State of America the largest producer (42%); Africa 6.5% with Nigeria the largest African producer[2] with nearly 8 Mt. Maize can be processed into thick porridge with different names based in many cultures: polenta (Italy), angu (Brazil), mamaliga (Romania), cornmeal mush (US), mealie pap (South Africa) and sadza, nshima and ugali or *ogi*, *akamu* and *ipekere* (Africa/ Nigeria). Maize can be eaten either as boiled or roasted or dried and prepared into a jelly-like pap or *eko* (maize grill) or fried into *ipekere* (maize cake). Despite its traditional importance, it contains poor/low protein content which limit the amounts of two essential amino acids (lysine and tryptophan), though it is very rich vitamins A, C and E, carbohydrates, essential minerals and dietary fibre[8].

Derivable maize products include *guguru* (pop-corn), *aadun* (maize snack), *kokoro* (corn cake), *donkwa* (maize-peanut ball) and *ipekere* (maize cake).

Ipekere is a local snack prepared from maize. It is largely consumed by most people in south-west Nigeria as nutritious meal for the family. It is usually prepared every morning by the road side sellers for economic purpose and income generation. The preparation of *ipekere* involves washing, wet-milling, balling/shaping and frying in hot palm oil which is marketed as fried snacks. *Ipekere* can be grinded into coarse form for livestock feeding. Frying confers a unique flavor, aroma and improve the quality of the maize snacks[9].

Optimization of the process variables such as frying (temperature) of the fermented wet-milled maize for *ipekere* production could enhance its nutritional quality, consistent color and sensory quality of the products[10,11]. Though, frying or heat treatment can result in the modification of physical, chemical and sensory characteristics of foods. Findings have revealed that frying of food affect the physical appearance (color) and the sensory quality of food products.

Traditionally, *ipekere* is produced in homes by local women using spontaneous or uncontrolled fermentation casually for ceremony and economic purposes. Different researchers have reported an improvement in the quality of cereal products obtained from fermentation method[3,4,12,13]. However, little or no information is available on the fermentation of maize grains for *ipekere* production. Therefore, this study is designed to evaluate the physicochemical properties and sensory evaluation of maize cake (*ipekere*) produced from maize (*Zea mays*) paste.

MATERIALS AND METHODS

Collection and preparation of samples: The varieties of maize (yellow and white maize) were purchased from Oja-Oba market in Akure, Ondo state, Nigeria. The samples were obtained in batches for 2 weeks in October, 2014. The maize kernels were peeled off from the corn, sorted and washed in sterile distilled water. The maize paste was produced by weighing 300 g of the washed maize kernel using different processing techniques: Blending, machine grinding and hand grinding by mixing with appropriate distilled water. After which the samples were stored prior fermentation.

Microbial analysis: The isolation of microorganisms from the maize pastes was carried out by ten-fold serial dilution and pour plating techniques. One gram each of the samples was weighed and aseptically dispensed separately into clean test tubes containing 9 mL sterilized distilled water, shake thoroughly for proper mixing and then serially diluted up to the appropriate dilutions. From the diluents, 0.1 mL aliquot was aseptically pipette into different sterile Petri-dishes and poured plated with already sterilized molten media. The plates were incubated at different temperatures and time (37°C for 24 h for bacteria and 28°C for 72 h for fungi). After incubation, the colonies and spores formed on the plates were counted and recorded. Pure culture of the isolates was obtained by sub-culturing on a fresh microbiological media. The isolates were identified based on their morphological appearance on the plates, microscopy and various biochemical tests.

pH determination: The pH of the fermenting maize samples was determined using pH meter Model 3015 (Jenway Ltd., England) by dipping the pH electrode into the filtered-fermenting maize samples solution inside 50 mL beaker and the readings were taken. The pH meter was standardized in a buffer solution of pH 4.0 and 9.0.

Total Titratable Acidity (TTA) determination: The TTA was determined by titrating 20 mL of the filtered-fermenting maize samples against 0.1 M NaOH using phenolphthalein as indicator until end point of permanent pink colour change is observed.

Determination of organoleptic properties of the maize samples: The organoleptic properties such as texture, aroma, taste and colour of the maize cake (*ipekere*) were assessed using a five-man panelist. The rating and scoring were done using a 5 point hedonic scale where, 5: Like extremely, 4: Like moderately, 3: Like slightly, 2: Dislike moderately and 1: Dislike extremely.

Statistical analysis: The analyses were carried out in triplicates. The data obtained were analyzed using analysis of variance ANOVA) and Duncan's Multiple Range Test (DMRT) was used to compare the treatment means using SPSS software (version 16.0 for Windows, SPSS Inc., Chicago, USA). Significance was accepted at $p<0.05$.

RESULTS

Total microbial counts: The total microbial counts from the fermenting maize samples are represented (Table 1). The microbial loads varied with each of the samples. The fermentation caused an increase in the microbial loads during the fermentation. The highest bacterial (7.0 CFU mL^{-1}) and fungal (4.5 sfu mL^{-1}) counts were obtained from yellow maize machine grinded at 120 and 96 h while the least bacterial counts (1.5 CFU mL^{-1}) and fungal counts (1.0 sfu mL^{-1}) were obtained from yellow maize blended and white maize blended and white maize blended respectively. No microbial growth was recorded in fermented yellow maize blended and fermented white maize machine grinded beyond 96 h.

Isolation and occurrence of micro-organisms from the fermenting maize samples: The micro-organisms isolated from the fermenting samples include *Bacillus subtilis*, *Lactobacillus fermentum*, *Staphylococcus aureus*, *Aspergillus niger*, *A. flavus*, *Neurospora crassa*, *Saccharomyces cerevisiae* and *Candida stellate* (Table 2, 3). *Lactobacillus fermentum* and *Saccharomyces cerevisiae* were predominant in all the samples. *Bacillus subtilis* and *A. niger* were isolated at day 1 and 2 while *Staphylococcus aureus* and *Candida stellate* were isolated only at day 1. *Aspergillus flavus* was isolated at day 1, 2 and 3 while *Neurospora crassa* occurred at day 2, 3 and 4, respectively (Table 4).

pH: The pH of the fermenting maize samples is represented (Fig. 1). The pH decreased with increase in fermentation time. White-maize blended, white-maize machine grinded and yellow-maize hand-grinded had high pH value 4.52 while the least pH value 3.0 was obtained from the white maize hand-grinded and yellow maize blended.

TTA: Figure 2 shows the total titratable acidity (TTA) of the fermenting maize samples. The TTA increased with increase in the fermentation time. The TTA values ranged from 0.06-0.19%. High TTA value 0.19% was obtained from fermenting white maize machine grinded while the least value 0.06% was obtained from yellow maize hand-grinded and white maize blended.

Organoleptic properties: Table 5 shows the organoleptic properties of *ipekere* from fermented maize gruel. The aroma/flavor, taste and overall acceptability were like moderately with no significant different ($p<0.05$) in their organoleptic properties. The texture and colour of the fermented maize cake were like slightly with great significantly different ($p<0.05$).

Table 1: Total microbial counts from the fermenting maize samples

	Bacterial counts (CFU mL^{-1})						Fungal counts (sfu mL^{-1})					
Time (h)	YM	YH	YB	WM	WH	WB	YM	YH	YB	WM	WH	WB
24	3.2	5.3	1.5	2.0	5.0	1.5	3.1	2.5	2.7	1.2	1.5	1.0
48	3.8	5.5	2.0	2.0	5.4	2.0	3.8	3.0	2.7	1.2	3.3	1.0
72	4.0	6.0	2.3	2.0	6.5	2.8	4.3	4.5	3.5	1.4	4.5	1.5
96	5.0	6.2	0.0	0.0	6.5	3.0	4.5	5.0	2.0	2.2	4.0	1.2
120	7.0	6.2	0.0	0.0	6.6	3.5	2.0	3.2	1.5	6.2	4.0	1.0
144	3.0	3.5	0.0	0.0	3.3	2.1	1.6	2.6	1.4	2.2	2.2	1.0
168	0.0	2.4	0.0	0.0	1.7	2.0	1.4	2.1	1.2	1.1	1.7	1.0

YM: Yellow maize machine grinded, YH: Yellow maize hand-grinded, YB: Yellow maize blended, WM: White maize machine grinded, WH: White maize hand-grinded, WB: White maize blended, CFU mL^{-1}: Colony forming unit per milliliter, sfu mL^{-1}: Spore forming unit per milliliter

Table 2: Morphological, characterization and identification of isolated bacteria from the fermenting maize samples

Test	Morphological characterization		
Shape	Rod	Rod	Cocci
Motility	-	+	-
Gram's reaction	+	+	+
Starch hydrolysis	+	+	+
Citrate utilization	-	+	-
Indole test	-	-	-
Catalase	-	+	+
Coagulase	-	+	+
H_2S	-	-	-
Glucose	AG	AG	AG
Fructose	AG	AG	AG
Lactose	AG	AG	AG
Maltose	AG	AG	AG
Sucrose	AG	AG	AG
Probable isolates	*Lactobacillus fermentum*	*Bacillus subtilis*	*Staphylococcus aureus*

+: Positive, -: Negative, AG: Acid and gas production

Table 3: Cultural, morphological and identification of fungi isolated from the fermenting maize samples

Isolate code	Cultural characteristics	Microscopic appearance	Probable fungal identified
RT	Greenish yellow	Mycelia growth and fully extended from the growth medium, from the entire surface. Conidiospores upright, simple, terminating in a globose or davate swelling bearing phialides at the apex and radiating	*Aspergillus flavus*
EP	Blackish	Black mycelia growth and fully extended from the growth medium, conidiospores upright, simple, terminating in a globose or davate swelling bearing phialides at the apex and radiating	*A. niger*
HQ	Pinkish	Conidia is coloured in mass dry basipetal chains. Number of irregular branches near the apex	*Neurospora crassa*
CM	Creamy	Blastoconidia are unicellular, globuse and ellipsoid, elongate in shape	*Saccharomyces cerevisiae*
VU	Creamy	Unicellular, spherical to ovoid, whitish film and cheese like	*Candida stellata*

Table 4: Occurrence of microbial isolates from the fermented maize samples

	Fermentation days						
Isolates	1	2	3	4	5	6	7
Bacillus subtilis	+	+	-	-	-	-	-
Lactobacillus fermentum	+	+	+	+	+	+	+
Staphylococcus aureus	+	-	-	-	-	-	-
Aspergillus niger	+	+	-	-	-	-	-
A. flavus	+	+	+	-	-	-	-
Neurospora crassa	-	+	+	+	-	-	-
Saccharomyces cerevisiae	+	+	+	+	+	+	+
Candida stellate	+	-	-	-	-	-	-

+: Present, -: Absent

Table 5: Organoleptic properties of *ipekere* from fermented maize gruel

	Sensory parameters				
Sample code	Texture	Aroma/flavor	Taste	Colour	Overall acceptability
YM	3.17±0.03[c]	4.60±0.02[a]	4.60±0.20[a]	3.80±0.01[b]	4.45±0.03[a]
YH	3.67±0.01[b]	4.60±0.02[a]	4.60±0.20[a]	3.40±0.00[a]	4.00±0.00[a]
YB	3.05±0.05[a]	4.00±0.00[a]	4.00±0.00[a]	3.60±0.10[b]	4.43±0.02[a]
WM	3.67±0.02[b]	4.80±0.03[a]	4.60±0.02[a]	3.20±0.10[a]	4.07±0.03[a]
WH	3.50±0.30[b]	4.60±0.02[a]	4.80±0.02[a]	3.20±0.10[a]	4.53±0.02[a]
WB	3.17±0.30[b]	4.20±0.09[a]	4.80±0.02[a]	3.00±0.00[a]	4.42±0.00[a]

Data are represented as Mean±standard deviation (n = 3) with the same superscript across the row are not significantly different ($p<0.05$), YM: Yellow maize machine grinded, YH: Yellow maize hand-grinded, YB: Yellow maize blended, WM: White maize machine grinded, WH: White maize hand-grinded, WB: White maize blended

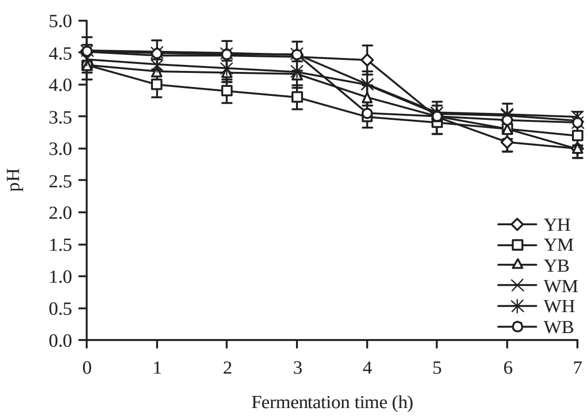

Fig. 1: pH values of the fermenting maize samples
YM: Yellow maize machine grinded, YH: Yellow maize hand-grinded, YB: Yellow maize blended, WM: White maize machine grinded, WH: White maize hand-grinded, WB: White maize blended

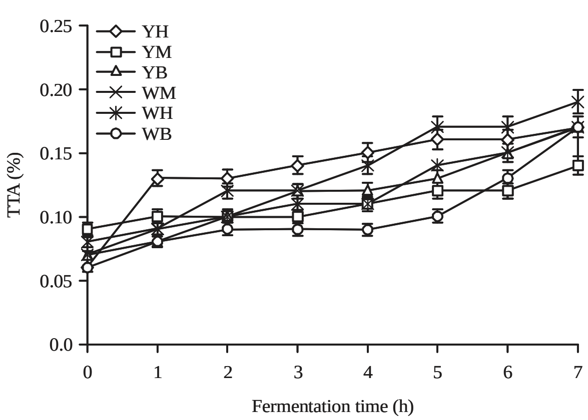

Fig. 2: Total titratable acidity (TTA) of the fermenting maize samples
YM: Yellow maize machine grinded, YH: Yellow maize hand-grinded, YB: Yellow maize blended, WM: White-maize machine grinded, WH: White maize hand-grinded, WB: White maize blended

DISCUSSION

In this present study, different micro-organisms were isolated from the fermented maize samples. The micro-organisms isolated such as bacteria, lactic acid bacteria and yeasts could be an inherent or natural microflora present in the samples. The microbial counts increased during the fermentation process. The increase in microbial loads might be due to the availability of nutrients in the substrates, ability of microorganisms to metabolize the substrate, suitable environmental conditions and absence of growth inhibitors in the fermentation medium. Different researchers have reported isolation of micro-organisms and their products from various fermented foods such as kenkey, *garri*, *agbelima*[2,12,14-18]. The micro-organisms isolated from fermented maize might be originated from the handlers/processors, processing utensils/equipments, surrounding environment and possibly from the water source and the grinding machine[2,19]. The addition of water to the substrates during grinding enhanced the increase in microbial population and their metabolism. The presence of these microorganisms enhanced the saccharification of the substrates at the initial phase of the fermentation depending on the chemical composition of substrates[18]. The occurrence of molds at the initial stage of the fermentation process and subsequent disappearance towards the end of the fermentation process had been reported[20]. The pre-dominant of lactic acid bacteria during the fermentation could be due to their ability to survive in a highly acidic condition, secreting organic acids such as lactic acid and utilization of the available substrates in the fermentation medium. Isolation of lactic acid bacteria from fermented foods such as kenkey, *garri*, *agbelima*, *fufu* and *ogi* etc. had been reported[8,18,21,22].

The variation observed in the microbial counts might be due to the availability of nutrients in the substrates, types of grains used and suitable environmental conditions and among other factors. The coexistence and symbiotic association between lactic acid bacteria and yeasts in most African traditional fermented products have been reported[23]. Besides their roles in the build-up typical flavor in fermented products, some yeast has been reported to show amylolytic, protease and phytase activities, the enzymes which help in breaking down maize starch and allowing better access to nutritionally essential minerals[24]. The molds isolated in the study are commonly present as contaminants in cereals and do not appear to play any significant role in the fermentation. Isolation of *Penicillium* spp. and *Aspergillus* spp. in maize fermentation during kenkey production has been reported[13].

The cause of increase in the acidity and consequent decrease in pH during fermentation of fermented foods might be due to utilization of free sugars by yeasts and lactic acid bacteria and secretion of organic acid into the fermentation medium[17,21].

Lactic acid bacteria grow at low pH. The presence of *Lactobacillus* spp. in the fermentation medium helps in the acidification of the fermenting substrate thereby inhibits the growth of spoilage and pathogenic micro-organisms[22]. The cause of the increase in acidity and subsequent decrease in pH during fermentation process might be due to utilization of free sugars by yeasts and lactic acid bacteria and secretion of organic acid into the fermentation medium[1,25].

The consumer's demand on the choice of consumables depends on the nutritional and sensory quality of such products. Sensory properties of foods greatly contribute to the acceptability of foods for man use. Like moderately acceptability of *ipekere* produced in term of aroma/flavor, taste and overall acceptability in all the maize samples were considered. The slight difference between the rating of the product (*ipekere*) obtained from the two samples might be mainly because the product obtained is familiar to the panelists which play an integral part in the panelist's response to the *ipekere*. Oyarekua[6] had earlier reported similar findings on the sensory quality of traditionally co-fermented cereals/cowpea mixtures as infant complementary food.

CONCLUSION

This study revealed the significance, importance and maize utilization for desirable products formation for man use. It also gave an insight into micro-organisms responsible for the traditional fermentation of maize for ipekere production. Also, the sensory quality shows that the ipekere is moderately accepted.

SIGNIFICANCE STATEMENT

Findings of this study will help to provide an information on the methods that could be employed in the production of quality maize cake (*ipekere*); the roles of fermenting microorganisms associated with cereal based fermented based foods and its physicochemical properties. Moreover, the sensory quality of the *ipekere* produced could enhance the consumer's choice for the product. However, this study will reveal the type of micro-organisms associated with fermenting maize sample for *ipekere* production and make available the information on the sensory quality of *ipekere* produced from maize varieties.

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