MAIZE PHARMACY OF SWEET CORN (*ZEA MAYS* L. CONVAR. *SACCHARATA* VAR. *RUGOSA*)

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ABSTRACT: *Sweet maize (Zea mays L. convar. saccharata var. Rugosa) is unique in sweet-taste, and pleasant flavour, hence the need to increase its usefulness and commercial values by enhancing its shelf-life and control of post-harvest losses. This preliminary study therefore simulated the traditional, natural, non-alcoholic, field-corn fermentation method for freshly-harvested yellow sweet corn into ògì, a fermented gruel or porridge food. Lactobacillus casei, Lactobacillus fermentum, Lactobacillus plantarum, and Saccharomyces cerevisiae predominated the naturally fermented ògì sample from sweet maize, with pH of 5.0–5.3. Observable characteristics of yellow sweet maize-fermented ògì were similar to those of yellow, field corn-fermented ògì. Present study is the first to report fermentation of sweet corn to ògì, indicative of sweet maize as a high potential plant substrate for health-promoting and nutritious fermented human diet, especially as prebiotics and probiotics, for lactating nursing mothers, convalescents, aged, and as weaning-food for infants or complementary food for children and adults.*

KEYWORDS: African fermented foods, complementary foods, IITA, lactic acid bacteria, maize pharmacy, *ògì*, sweet corn fermentation.

INTRODUCTION

Maize or corn (*Zea mays* L.), an important annual cereal crop belonging to family Poaceae (Shah *et al*., 2016), is grown globally in a wider range of environments because of its greater adaptability (Swapna *et al*., 2020; Revilla *et al*., 2021). It is considered one of the three leading staple crops (including rice and wheat) in many parts of the world (Sandhu *et al*., 2007; Olaniyan, 2015; Swapna *et al*., 2020). Furthermore, fermentation of maize kernels has been one of the most important maize processing as a simple and affordable strategy for decreasing their anti-nutritional factors, improving the nutritional properties, and preserving maize-based products (Marshall & Mejia, 2012). Non-alcoholic fermentation of maize by lactic acid bacteria and yeasts is a food preservation methods that has been utilised throughout the centuries, in the production of many fermented foods, beverages, animal feeds, cornmeal, grits, starch, flour, tortillas, snacks, breakfast cereals, etc (Shah *et al*., 2016; Mashau *et al*., 2021). Being globally sourced for its nutrition and phytochemical compounds, maize is also reportedly quite vital for preventing various diseases (Shah *et al*., 2016). More so, different maize varieties had been previously fermented into *ògì* and other similar African fermented foods, through natural or starter-culture fermentation processes, except sweet corn, though a cultivated plant grown for human consumption.

Sweet maize or sweet corn (*Zea mays* L. *var*. *saccharata* or *Zea mays convar*. *saccharata* var. *Rugosa*) is a maize variety with high sugar content, as a result of the naturally occurring recessive mutation in the maize genes, which controls conversion of sugar to starch inside the endosperm of the corn kernel (Erwin, 1951; Adetimirin, 2007; Panchal *et al*., 2017; Swapna *et al*., 2020; Adamczewska-Sowińska *et al*., 2021; Wikipedia, 2023). Three major genotypes/varieties of sweet corn are standard sugary [su], super sweet [sh2], and sugar-enhanced [se] (Adamczewska-Sowińska *et al*., 2021). They differ in sweetness, keeping quality, and seed vigour, but super sweet or shrunken-2 sweet corn contains up to twice the amount of sugar in standard varieties (Adamczewska-Sowińska *et al*., 2021) (https://hortnews.extension.iastate.edu/faq/what-are-differences-between-various-types-sweet-corn).

Sweet corn are usually picked when in the immature (milk), plumpy stage, before the kernels become mature and tough, so that sugar is not converted to starch, and as well, they are also eaten as a vegetable at the milk stage, rather than as grain, and consequently, large amounts of simple sugars and disaccharides are retained in the kernels at this stage (Schultheis, 1994; Lima *et al*., 2019; Adamczewska-Sowińska *et al*., 2021; Demeter *et al*., 2021). The main beneficial characteristics and high economic importance of sweet maize is due to its suitability for direct consumption, adequate kernel texture at optimal maturity, sweet taste, and high biological values, antioxidants contents (e.g., vitamin C and E content, carotenoids, and mineral salts). The economic importance of sweet corn includes its use in the manufacture of several by-products like cosmetics and glucose from starch, oils, glue, paints, varnishes, and paper from fibres, while its stalks and other residues are an important livestock feed (Ngenoh *et al*., 2015; Natalia *et al*., 2018; Adamczewska-Sowińska *et al*., 2021). In terms of nutrition, sweet corn succulent silks are rich in energy, protein, and vitamin.

In Nigeria, fresh sweet maize is mostly directly eaten from the cob, after boiling, steaming or roasting the maze cobs, with intact husks or de-husked. At times, it is eaten raw on the farm or immediately after harvesting, and the kernels can also be boiled with beans, pepper, and oil, as beans-maize porridge or commonly added to salads, fried rice, and occasionally, *jollof* (a type

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of pepper-coloured) rice, in form of freshly canned or frozen vegetable. The yellow sweet maize variety is the most commonly planted in Nigeria, but it is not yet as popular as expected, considering its unique sweet taste and pleasant flavour. Apart from being one of the most-popular vegetables in the western and advanced countries (Swapna *et al*., 2020), it is a highly perishable vegetable, with short shelf life; so, efforts are needed to promote processing of sweet maize, in order to increase its usefulness and commercial values, enhance its shelf-life, and prevent post-harvest losses (Swapna *et al*., 2020). This preliminary study therefore attempts the possibility of natural, non-alcoholic fermentation of the yellow sweet corn into *ògì*, a fermented cereal food.

METHODOLOGY

Non-Alcoholic Fermentation of Yellow Sweet Maize Kernels into *Ògì* Mesh

Freshly-harvested yellow sweet maize cobs
↓
Freshly-harvested yellow sweet maize kernels from cobs
↓
Steeping in water at room temperature (2 days)
↓
Draining of steeped yellow sweet maize kernels
↓
Wet-milling steeped sweet maize into maize mesh
↓
Sieving of maize mesh
↓
Fermentation of maize mesh (3 days)
↙ ↘
Ògì paste *Ògì* filtrate

Figure 1: Flow chart of non-alcoholic fermentation of yellow sweet maize into *ògì*

Freshly harvested yellow sweet maize cobs were bought from the research unit of Prof. V.O. Adetimirin, Department of Agronomy, University of Ibadan, Nigeria. The kernels were removed manually by hand, steeped (uncovered) in cold water for two days at room temperature, after which the steeped kernels were drained, then wet-milled into maize mesh, with a very clean grinder. The milled maize mesh was sieved and then passed through non-alcoholic fermentation into *ògì* paste, for additional three days, while the sieved chaff was discarded (Figures 1–7).

pH and Coliforms Determinations in Sweet Maize Fermented *Ògì* Sample

The pH of the fermented sweet maize was initially determined using the universal indicator strips, and confirmed by standardised Pye-Unicam pH meter 292 MKII with an attached electrode. Indicator enterobacteria were determined with coliform assay, using sterile MacConkey broth (Lab M, England). The result was considered positive, if the MacConkey broth turned yellow from pink colour, and there was displaced broth (to gas) in the inverted

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Durham tubes within 48h, after incubation at 35–37^{0}C or 45^{0}C, which is indicative of the presence of total or faecal coliforms respectively, and designated as a breach in food safety.

Isolation and Characterisation of *Lactobacillus* and *Saccharomyces cerevisae* Strains in Sweet Maize Fermented *Ògì* Sample

Ògì samples obtained from fermented yellow sweet maize kernels were isolated on MRS (de Man, Rogosa and Sharpe, Lab M, England) broth and agar, while phenotypic taxonomy of the pure cultures into *Lactobacillus* species were according to standard protocols, on the basis of their cultural, morphological, biochemical, and physiological characteristics (de Man, Rogosa & Sharpe, 1960; Sharpe & Fryer, 1965; Rogosa, 1970, 1974; Enfors *et al*., 1979; Sharpe, 1981). *Saccharomyces cerevisiae* strains were isolated on buffered yeast extract agar, and also phenotypically identified, using appropriate taxonomic tools, including cultural, biochemical, and physiological indices (Kreger-van Rij, 1984; Barnett *et al*., 1990; Kurtzman *et al*., 2010).

RESULTS / FINDINGS

In this study, *ògì* was produced from yellow sweet maize kernels, simulating the traditional fermentation method of fermenting field corn (Figure 1). Observable characteristics of the sweet maize fermented *ògì* were extremely similar to the regular field corn fermented *ògì* (Figures 4 & 5), but more fibrous shafts were observed after sieving the wet-milled sweet maize mesh (Figure 6), compared to the field maize shafts, which served as control. Prior to fermentation, the sugary taste of raw yellow sweet corn (*Zea mays* convar. *saccharata* var. *rugosa*) at the milk stage was distinctly different from the sugary taste of the raw field corn (*Zea mays* L.) at the milk stage.

Figure 2: Loose kernels of sweet corn

Figure 3: Steeped kernels of sweet corn

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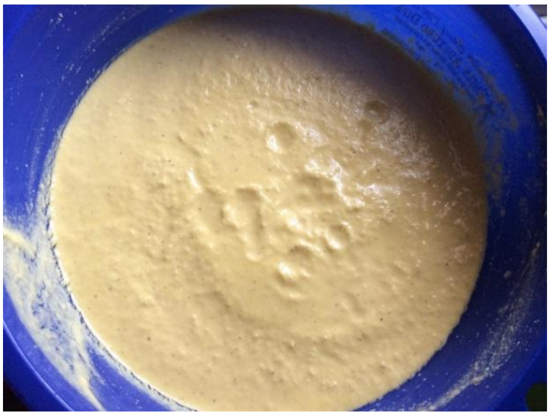

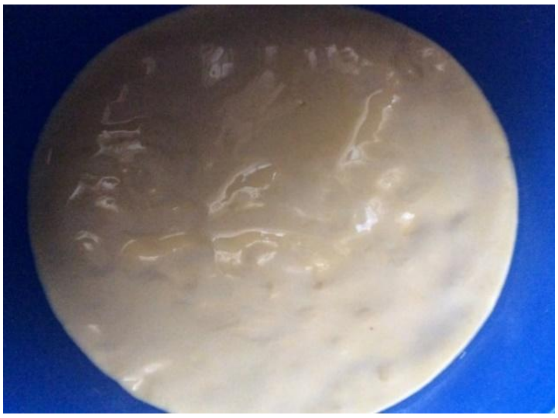

Figure 4: Unsieved maize mash for production **Figure 5:** Sieved maize mash for production

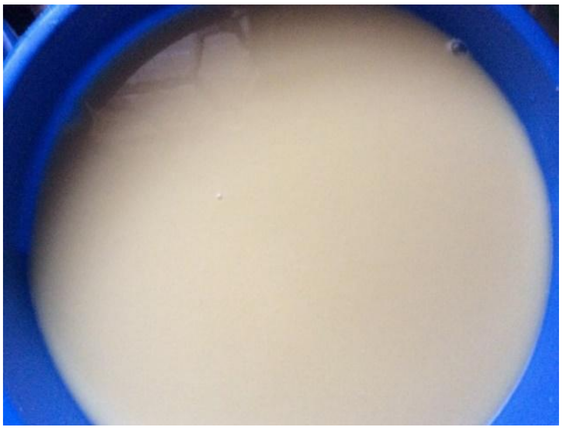

Figure 6: Sieved milled sweet maize shaft **Figure 7:** *Ògì* filtrate (*omi* ‘*dun*)

The pH values of the sweet maize fermented *ògì* samples were 5.0 and 5.3, while the vended field corn fermented *ògì* samples were in the range of pH 6.7–6.9, and some were above pH 7.0. *Lactobacillus casei*, *Lactobacillus fermentum*, *Lactobacillus plantarum, and Saccharomyces cerevisiae* predominated during the natural fermentation *of yellow sweet maize kernels into ògì*.

Only two out of eight coliform tubes containing samples of the sweet maize-fermented *ògì* turned slightly yellow after 56 hours incubation, but without displacement of MacConkey broth in the inverted Durham tubes. In that wise, therefore, sweet maize-fermented *ògì* in this study did not harbour total or faecal coliforms, while very minimal indication of lactose-fermenting enterobacteria (after 56 h of incubation at 35^0–37^0C) were detected.

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DISCUSSION

In most African countries, cereal grains are rich sources of nutrients like carbohydrates, protein, dietary fibre, minerals, B complex vitamins, soluble fibre, etc. Major components of corn kernels include endosperm (containing health-promoting compounds like amylase), germ and bran, each containing high concentrations of a wide range of phytochemicals, such as, total phenolics, and phenolic acids like vanillic acid, syringic acid, coumaric acid, ferulic acid, and caffeic acid (Blandino *et al*., 2003; Fernandes *et al*., 2018; Sheng *et al*., 2018; Adebo *et al*., 2019; Munekata *et al*., 2020). These high nutritional properties of different fermented West African maize-based foods and beverages thus have beneficial influence on the health, and are thereby quite popular. Various supplementations and/or bio-fortifications have also been carried out on fermented foods and beverages from maize, as the indigenous/traditional production technology of the fermented food products has evolved to industrial production (Steinkraus, 2002; Snout, 2009; Enwa *et al*., 2011; Mashau *et al*., 2021). Sweet corn is however hardly consumed as processed food products, and none of the currently available literature reported usage of sweet corn as fermented grain, except for this study, which attempted to produce a fermented food product from sweet maize.

Predominating microbial flora (*Lactobacillus casei*, *Lactobacillus fermentum*, *Lactobacillus plantarum, and Saccharomyces cerevisiae*), during the natural fermentation of yellow sweet maize kernels *into ògì*, have also been reportedly beneficial in food fermentations and human health. Sweet maize fermented *ògì* is therefore a potential food source for probiotic candidates and bioactive compounds, which can be therapeutic in infantile nutrition and health (Ogunshe, 2006; Ogunshe *et al*., 2011). The low pH of the sweet maize fermented *ògì* makes it a low-acid fermented food, as the fermenting microorganisms must have used the easily available sugars in the milled sweet maize mesh during *ògì* fermentation, resulting in pH of 5.0 and 5.3. In addition to being a very vital means of improving the nutritive and preserving values of sweet maize, the acidic pH after fermentation must have also contributed to very low presence of food-borne indicator bacteria. This is unlike many street vended, field corn-fermented *ògì* samples, which harboured total and faecal coliforms (Ogunshe & Gbadamosi, 2011), presumably from water used in steeping the maize kernels, as similar contamination of fermented food products by processing water samples had been earlier reported (Ogunshe & Okereh, 2011).

Higher fibre (shaft) mass of the milled sweet maize (Figure 6) is also indicative of additional nutritional benefit, especially in the circumstances of intense food insecurity. Furthermore, it is a common historical health belief in Nigeria, particularly in South Western Nigeria, that hot *ògì pípò* (Yoruba) or *àkàmù* (Hausa), which is, boiled, paste-like slurry pap (porridge), is highly beneficial during maternity period for enhancing the production of more breast-milk by nursing mothers of newly born babies. Sweet maize-fermented *ògì* can therefore serve as weaning food for infants, complementary food for children, and nursing mothers, prebiotics, and also as probiotics (living microorganisms that contribute to the host's overall health when consumed in adequate amounts). *Ògì tútù* (wet unboiled pap) is common in aiding the stoppage of loose stool and for treatment of topical dermal wounds, including skin scarring, due to hot water or fire. *Ògì rírò* or *ògì sísè* (cooked, set pap) is also popular among the convalescents as a common hospital food for patients. Sweet maize fermented *ògì* would therefore be a highly potential human diet for all, thereby enhancing the shelf-life of sweet maize and preventing its post-harvest losses.

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IMPLICATION OF STUDY TO RESEARCH AND PRACTICE

According to Kumar *et al*. (2013), *Zea* is an ancient Greek word meaning *sustaining life*, and *Mays* is a word from Taino language (Caribbean) meaning *life giver*. The word maize is derived from the Spanish connotation, *maiz,* which was the best way of describing the plant (Shah *et al*., 2016). Much earlier, higher returns and opening opportunities for employment generation were noted to be responsible for maize growers' shifting to specialty corn production, among which was the sweet corn, with its very big market potentials, great genetic variability, and ability to improve its nutritive value (Swapna *et al*., 2020). Based on all the afore-mentioned characteristics of sweet maize, which confirm its global importance as well as a new scientific information provided by findings of this preliminary study that fermentation can also be a means of preserving the highly perishable sweet maize grain/vegetable, by serving as a grain substrate for food fermentation, which is a form of food security. This may also play a key role in sweet corn being one of the farm produce to be extensively promoted in farm ventures by the Institute of Tropical Agriculture (IITA), Nigeria, indicating its enormous importance in tropical agriculture. Fermentation of sweet corn can also be applicable in the production of other African maize-based fermented foods like *abreh* (Sudan), *uji* (Kenya), *mawe*, *banku*, *kenkey* (West Africa), *togwa* (East Africa), *mahewu* (South Africa/some Arabian Gulf countries), etc.

CONCLUSION

This preliminary study is the first to report on the fermentation of sweet maize (*Zea mays* L. convar. *saccharata* var. *rugosa*), to produce *ògì*, a non-alcoholic, fermented food, with low a pH of 5.0–5.3 and predominant *Lactobacillus casei*, *Lactobacillus fermentum*, *Lactobacillus plantarum* and *Saccharomyces cerevisiae*. *Ògì*, from sweet maize, has not only added to the uniquely diverse culinary values of sweet maize but also its preservation value and potential ability as a plant substrate for health-sustaining functional fermented food product, with nutritional characteristics in human diets.

FUTURE RESEARCH

As a follow-up to this study, detailed isolations of all microbial species associated with the fermentation of yellow sweet maize into *ògì*, and their roles in the fermentation process, are to be investigated in future research.

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