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MICROBIOLOGICAL ASSESSMENT, PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES OF *AGIDI* PRODUCED IN AKOKO AREA OF ONDO STATE

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Abstract

This study was carried out to determine the microbial, physico-chemical and functional properties of agidi, a fermented maize product sold in Akungba-Akoko, Ikare-Akoko, Oka-Akoko and Ugbe-Akoko in northern region of Ondo State. The bacteria isolated from the samples were Lactobacillus plantarum, L. acidophilus, Leuconostocmesenteroides, Micrococcus luteus, Pediococcusspp, and Staphylococcusaureus while the fungi includeAspergillusflavus, Saccharomyces cerevisiaeand Candida krusei. All the lactic acid bacteria and S.cerevisiae were isolated in all the samples while S.aureus, A. flavus and Micrococcusluteus were isolated from Oka sample alone. Akungba sample had the highest pH of 4.24 while the lowest pH of 4.02 was found in Oka sample. However, the highest TTA (1.44%) was found in Oka sample while the lowest content of 0.99% was from Akungba sample. Highest bulk density was obtained in Ikare sample (2.64gml^{-1}) while the least value was from Oka sample (1.53gml^{-1}). The highest content of water absorption capacity was obtained from Ikare sample (0.8g/g) while the least value was recorded from Oka sample (0.4g/g). The foaming capacity values of all the samples were found to reduce with increase in time for all the agidisamples. The least gelation capacity and the viscosity were obtained from Ikare samples while the highest values were obtained from Ugbe and Akungba samples respectively. All the sensory parameters studied were not significantly different ($p<0.05$). There is need to maintain proper hygiene during the processing of some of these locally fermented foods so as to avoid potential pathogens.

1.0 Introduction

Cereals provide a major source of foods for human beings globally. Cereal provides more than 70% of common dietary energy in many areas of the world including Africa and Asia In Africa sorghum and maize are the most popular cereals which can be processed by many techniques for adults and infants, and even for the sick [1]. They can be processed into different forms thereby introducing variety into consumption of such staples [2]. Fermented cereals form a substantial part of the diets in many African countries. In developing countries, fermented foods are produced primarily in homes, villages and scale cottage industries where they find wide consumer acceptance. Among the locally fermented cereal foods include *ogi, burukutu, pito, masa, and kunu-zaki*and*agidi* [3, 4, 5]. The fermentation process of staples serves as a means of providing a major source of nourishment for large rural population. This contributes significantly to food security by increasing the range of raw materials which can be used in the production of edible products [6]. Fermentation enhances the nutrient content of foods through the biosynthesis of vitamins, essential amino acids and protein by improving protein quality and fiber digestibility [7]. It also enhances micronutrient availability through degrading anti-nutrient factors [8]. The use of biological and natural means to enhance the nutritive value of food products has greater safety advantages over chemicals because biotechnological synthesized products are less toxic.

Agidi is a gel-like traditional fermented starchy food item produced from maize (*Zea mays*), although millet and sorghum can also serve as raw materials. Its colour depends on the substrates used; it is creamy to glassy white from maize, light brown from sorghum and grey to greenish colour from millet. It is becoming very popular, with acceptability cutting across the various multi-ethnic groups and socioeconomic classes [9]. The ease of consumption alone or with soup, stew, beans cake (*akara*), moi-moi, as light meal especially amongst post-operative patients and other patients in the hospitals makes it very popular. *Agidi* has economic potentials especially now that emphasis is on development of local foods. Traditionally, *agidi* can be produced first by washing and steeping the maize grains in clean water for 2 or 3 days. The softened grains are then wet-milled into fine slurry which is subsequently sieved using a muslin cloth. The resulted pomace is discarded while the sieviate is allowed to settle in a plastic bucket and ferment for 2 to 3 days. The starch paste is called *ogi*. On addition of water, the boiled and cooked *ogi* with continuous stirring give stiff gel known as *agidi*. The resulted *agidi* is wrapped and then allowed to coolbefore serve (Figure 1). Despite the advancement of science and technology in Africa, the production of fermented foods including *agidi* is still largely a produced using traditional technique [2]. These crude forms of processing encourage high microbial contamination which at times could lead to contamination by spoilage and pathogenic microorganisms. This study was therefore carried out in order to evaluate the microbial contents and safety status of agidi produced from Akungba, Ikare, Oka and Ugbe communities in Akoko area of Ondo State.

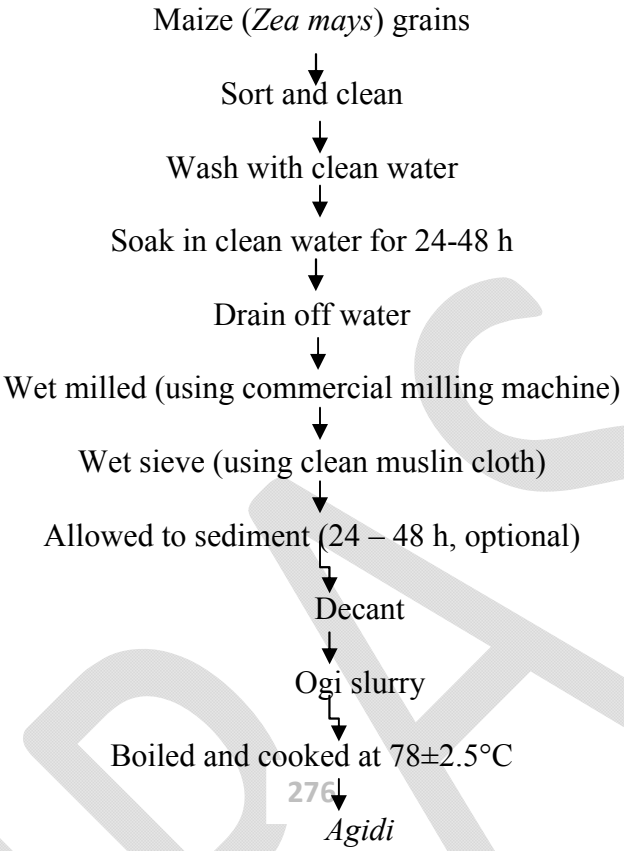

Figure 1: Traditional method of processing *agidi.*

2.0 Materials and Methods

2.1 Samples Collection

The fermented maize slurries prepared for the production of agidi were sourced from four different communities in the Akoko area (Akungba, Oka, Ikare and Ugbe) of Ondo State, Nigeria. The slurries were immediately transported to the Microbiology Laboratory, AdekunleA jasin University, Akungba-Akoko, Ondo State.

2.2 Isolation and enumeration of microorganisms

Microorganisms from the samples were isolated by preparing stock cultures containing 5 g of each sample properly homogenized in 45 ml of sterile distilled water. The samples were further serially diluted (ten-fold) up to the appropriate dilutions and plated out using pour plate technique. Bacterial plates were incubated at 37^{o}C for 24 to 48 hours while fungal plates at 28^{o}C for 72 to 120 hours. The colonies on the plates were enumerated and recorded. Pure cultures of the isolates were obtained by repeated streaking on the appropriate media and their respective slants were kept in the refrigerator at 4^{o}C for further use. The microorganisms were identified based on their cultural characteristics and biochemical tests [10].

2.3 Determination of pH and Total Titratable Acidity (TTA)

The pH and TTA were determined according to the method of AOAC [11].

2.4 Determination of the functional properties of*agidi*

The bulk density of the samples was determined according to Zakari*et al*[12] while the foaming capacity and gelation were determined using Coffman and Garcia [13]. Water absorption capacity was determined using the method described by Sefa-Dedeh*et al*. [14].

2.5 Sensory evaluation

The sensory evaluation of the samples was carried out by a panel of ten people comprising the students and staff of Microbiology Department, AdekunleAjasin University, AkungbaAkoko, Nigeria who were familiar *agidi*. The parameters evaluated were taste, aroma, texture, appearance, firmness and the overall acceptability using 9- hedonic scale ranging from 9 = like extremely to 1 = dislike extremely [15].

2.6 Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA), the means being tested for significance at $p<0.05$ using Duncan's multiple range (DMR) test.

3.0 Results and discussion

Table 1 shows the bacterial counts of each sample. Ugbe has the highest total viable counts of 6.2×10^6 cfu/g while the lowest count of 3.8×10^6 cfu/g was recorded from Ikare sample. The highest and the lowest lactic acid bacterial counts of 4.2×10^6 and 2.8×10^6 were also obtained from Ugbe and Ikare samples respectively. Ikare sample had the highest fungal counts (6.5×10^4sfu/g) followed by Akungba sample (3.5×10^4sfu/g) while the least count was found in Oka sample (2.5×10^4sfu/g).

Table 1: Microbial counts of *agidi* samples from Akoko area of Ondo State

Samples	Bacteria counts (cfu/g)	Lactic acid bacterial counts (cfu/g)	Fungal counts (sfu/g)
Akungba	4.5×10^6	3.6×10^6	3.5×10^4
Ikare	3.8×10^6	2.8×10^6	6.5×10^4
Oka	5.5×10^6	3.2×10^6	2.5×10^4
Ugbe	6.2×10^6	4.2×10^6	3.0×10^4

Forty four microorganisms were isolated from the *agidi*samples they include five genera of bacteria and three genera of fungi. The bacterial genera include *Lactobacillus plantarum, L. acidophilus, Leuconostocmesenteroides, Micrococcus luteus, Pediococcus*spp, and *Staphylococcusaureus* while the fungi include*Aspergillusflavus, Saccharomyces cerevisiae*and *Candida krusei*(Table 2). All the lactic acid bacteriaA isolated were present in all the samples but with more predominance of *L. plantarum*. Besides, *S. cerevisiae* was also present in all the samples. *Micrococcus luteus, S. aureus*and *A. flavus* were isolated from Oka sample alone while *C. krusei* was isolated from Oka and Ugbe samples alone

Table 2: Occurrence of microorganisms in*agidi*samples from Akoko area of Ondo State

Isolate	Akungba	Ikare	Oka	Ugbe
Lactobacillus plantarum	+	+	+	+
Lactobacillus acidophilus	+	+	+	+
Leuconostocmesenteroides	+	+	+	+
Pediococcus	+	+	+	+
Micrococcus luteus	-	-	+	-
Staphylococcus aureus	-	-	+	-
Saccharomyces cerevisiae	+	+	+	+
Aspergillusflavus	-	-	+	-
Candida krusei	-	-	+	+

Key: - = absent, + = Present

The highest pH of 4.24 was obtained from Akungba sample, followed by Ugbe sample which contained 4.17 while Ikare and Oka samples contained 4.11 and 4.02 respectively.

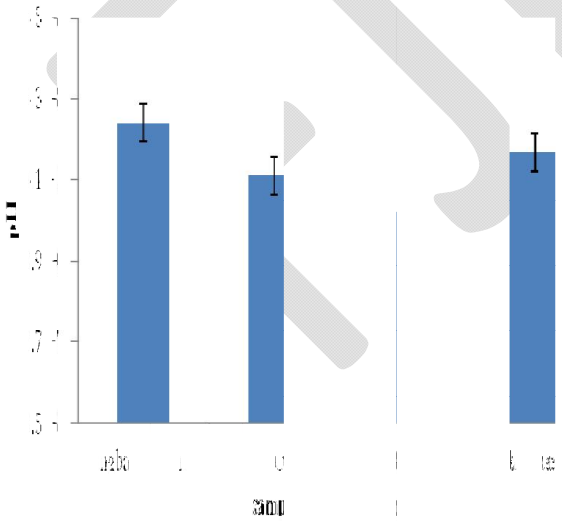

Figure 1: The pH of *agidi* samples from Akoko area of Ondo State

The results of the TTA of the samples revealed that Oka sample had the highest value (1.44%) while Ikare, Ugbe and Akungba samples contained 1.26%, 1.17% and 0.99% respectively.

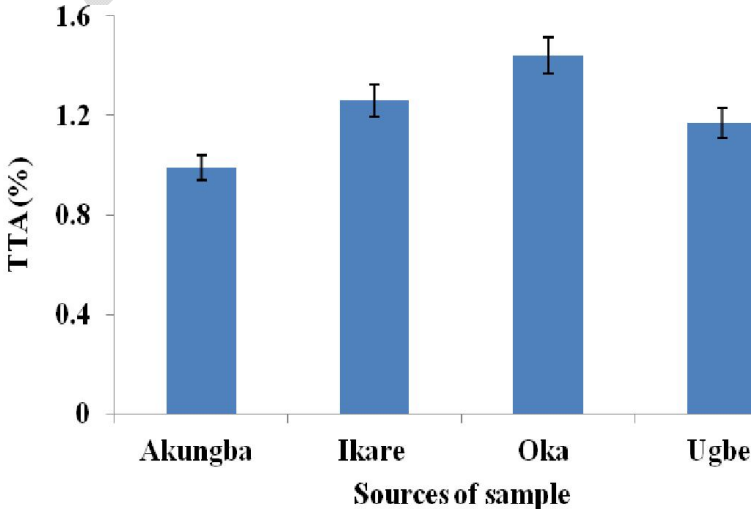

Figure 2: The Total titratable acidity of *agidi* samples from Akoko area of Ondo State

The highest value of bulk density was obtained from Ikare sample (2.64) followed by Ugbe sample (2.24) both which were not

significantly different ($p<0.05$). The bulk density obtained from Akungba sample which was 1.72, was significantly lower ($p<0.05$)than those determined from the latter samples but significantly higher ($p<0.05$) than Oka sample which contained 1.53. The water absorption capacity of sample from Ikare was the highest (0.8) followed by Ugbe sample (0.6) while the lowest value of 0.4 was obtained from Oka sample but was not significant different ($p<0.05$) from Akungba sample which contained 0.5. The usual reductions were observed in the foaming capacity of all the samples with time. The values obtained from Akungba and Ikare samples were not significantly different ($p<0.05$) at 30 seconds intervals up to 180 seconds. Similar trends of foaming capacity were observed in Oka and Ugbe samples but significantly lower ($p<0.05$) what were obtained from Akungba and Ikare samples. The highest gelation (12%) was obtained from Ugbe sample while the Ikare sample recorded the least value 7%. The gelation obtained from both Akungba and Oka samples (10%) were not significantly different ($p<0.05$).

Table 3: The functional properties of*agidi*samples from Akoko area of Ondo State

Sample	BDY	WAC	FMC (%) Time (Sec)				GEL (%)	Viscosity
			30	60	120	180		
Akungba	1.72±0.01^{c}	0.5±0.00^{c}	5.64±0.01^{b}	4.60±0.10^{b}	3.40±0.01^{b}	3.00±0.02^{b}	10.00±0.002^{b}	1.31±0.00^{a}
Ikare	2.64±0.01^{a}	0.80±0.00^{a}	5.70±0.01^{b}	4.50±0.02^{b}	3.30±0.01^{b}	3.10±0.01^{b}	7.00±0.01^{c}	1.22±0.00^{b}
Oka	1.53±0.01^{d}	0.40±0.00^{c}	6.67±0.01^{a}	5.52±0.01^{a}	4.40±0.01^{a}	4.25±0.01^{a}	10.00±0.04^{b}	1.26±0.01^{b}
Ugbe	2.24±0.00^{ab}	0.6±0.01^{ab}	6.72±0.02^{a}	5.66±0.01^{a}	4.50±0.01^{a}	4.30±0.01^{a}	12.00±0.02^{a}	0.94±0.00^{c}

Mean values with the same superscript down the column are not significantly different ($p<0.05$).

KEY:FMC- foaming capacity, WAC- water absorption capacity, BDY- bulk density, GEL- gelation. Table 4 shows the sensory parameters of the samples. There was no significant difference ($P<0.05$) in any of the determined. *Agidi* sample from Akungba was rated best (6.6) with respect to taste followed by Ikare and Ugbe sample we were rated same, while Oka sample was scored 6.2. Aroma and texture were scored best in Ikare sample with respective scores of 6.7 and 6.1 while Ugbe sample samples from Ugbe and Oka were rated lowest with respective scores of 5.7 and 6.2. Akungba and Ikare sample were rated same with respect to appearance while Oka sample had the lowest value. The firmness grades ranged from 6.2 to 6.6 in which Akungba and Oka samples were rated lowest and highest respectively. The results of the overall acceptability grouped Akungba and Ikare samples as the most acceptable while Oka and Ugbe were also rated same as second and less**.**

Table 4: Sensory properties of*agidi*samples from Akoko area of Ondo State

Sample	Taste	Aroma	Texture	Appearance	Firmness	Overall acceptability
Akungba	6.6±0.01[a]	6.6±0.01[a]	5.8±0.10[a]	6.6±0.04[a]	6.4±0.06[a]	6.5±0.10[a]
Ikare	6.4±0.02[a]	6.7±0.03[a]	6.1±0.02[a]	6.6±0.04[a]	6.6±0.01[a]	6.5±0.04[a]
Oka	6.2±0.04[a]	6.4±0.02[a]	6.0±0.00[a]	6.2±0.02[a]	6.2±0.02[a]	6.2±0.03[a]
Ugbe	6.4±0.02[a]	6.2±0.04[a]	5.7±0.05[a]	6.4±0.01[a]	6.4±0.03[a]	6.2±0.01[a]

Mean values with the same superscript down the column are not significantly different ($p<0.05$)

Fermented foods which contain adequate nutrients could serve as rich substrates for the growth of pathogenic microorganisms. Isolation of diverse microorganisms from fermented foods could be due to their various roles during the fermentation process. All the lactic acid bacteria, *S. cerevisiae* and *Candidakrusei* isolated in theses samples have been implicated in many cereal base fermented foods. Ejike and Ijeoma[16] and Idowu*et al*. [17] isolated *Lactobacillus*spp and *Saccharomyces*spp while fermenting maize for *ogi* and *mahewu* production respectively.*Lactobacillus*and *Saccharomyces*species have been reported to enhance acidity,flavour development and antinutrient reductions in fermented foods [18;19].Fermentation involving lactic acid bacteria could lead to the reduction in proteinase inhibitors in some cereal products thereby releasing essential amino acids such as lysine, methionine and tryptophan into such foods [20]. The presence of *Micrococcus*spp, *Staphylococcus* spp and *Bacillus*spp in Ugbe and Oka samples could be due to contamination arising from improper personal hygiene of the handlers as well as the utensils used for their production [21]. However, theirabsence in other samples might be due to proper hygienic practices during their production or they were eliminated by antimicrobial substancessuch as organic acids produced by lactic acid bacteria [22]. The relatively close range of microbial counts of the samples could be due to the fact that they were produced from the same substrate using the same or similar techniques.

The low pH of some fermented foods could be attributed to the proliferation of microbial biomass particularly lactic acid bacteria and yeast capable of utilizing free sugars to produce organic acids [23]. There was a possibility of higher lactic acid bacteria and the yeasts in *agidi* from Oka than the other samples. Idowu*et al*. [17] reported low final pH values while producing *mahewu,* a fermented maize product. The reduction in pH in some fermented foods could be responsible for the elimination/reduction of bacterial pathogens under fermentation conditions.

Bulk density is a function of particle size which is a reflection of the total load the samples can carry if allowed to rest directly on one another [24]. The bulk density of processed foods influences the texture or mouth feel, the strength, type of packaging material required and the mixing quality of such foods [25]. The bulk density obtained from all the samples were higher than that obtained by Edema and Sanni [26]and Adebowale and Maliki [27] from soya bean and pigeon pea seed flour respectively. The variation observed in the bulk densities of the samples might be due to the differences

in their particle sizes and their starch contents [28]. Higher bulk density helps in dispensability thereby contributing to the greater packaging advantage [29]. However, food products with low bulk density are desirable in formulating complementary foods for infant weaning [30]. Besides, foods with low bulk density may result in high consumptionand the reduction in the cost of packaging and transportation [4].

Gelling property is the ability of food samples to absorb water and swell thereby providing consistency in food preparation especially semi-solid products [31]. Variation in the gelling properties of the *agidi*samples could be attributed to the relative ratios of different constituents including proteins, carbohydrates and lipids that make up the flours and the interaction between the components [27; 32]. Gelation occurred more readily at higher protein concentration because of greater intermolecular contact during heating [33].High protein solubility conformations, disulfide linkages and hydrophobicity have all been reported to play significant roles in gelation. Bolaji*et al*. [4] reported least gelation concentration 8% for maize *ogi* which was within the range obtained in the research. The foaming tendency of foods depends on the presence of flexible protein molecules which may decrease the surface tension of water [34]. Apiah*et al*. [24] reported foaming to improve the texture, consistency and appearance of foods. The low values of foaming capacities are indicative of soluble proteins and indicative of low gas/volume ratio. Water absorption capacity helps in determining the amount of water needed for products consistency depending on the structural composition of the sample. High value of water absorption capacity is desirable for the improvement of mouth feel and viscosity reduction in food product. The variation and significant differences($p<0.05$)in the water absorption capacities of the samples may be attributed to the differences in their particle sizes, amylase/amylopectin ratio, varieties of the samples, processing and storage conditions and the degree of availability of water binding sites among the starches [35]. The differences in the water absorption capacities in each of the samples may be due to their hydrophilic constituents such as carbohydrates, which bind more water than protein and lipids. The result obtained from this study was similar to the findings of Ufot and Winifred [34] who reported 0.86 water absorption capacity of 100% maize *ogi*. The significant differences ($p<0.05$)observed in the viscosities of the samples might be attributed to different rates of water absorption and swelling of starch granules in the samples [36]. High viscosity in Akungba sample might be attributed to its ability form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear stress during stirring [37]. The low viscosity might be due to the degradation of starch by thehydrolyzing enzymes (α and β amylases) that developed during the fermentation process [38]. Consumption of low viscous thin gruel may result in higher intake and subsequent high demand for such products [12]. Improvement in the sensory parameters of most fermented foodsenhancestheir quality and acceptability which could be attributed to the adequate processing techniquesused for their production. The consistency in the appearances, colour and texture could prompt flair for such food mostly among the rural and the urban dwellers. The improvement in the sensory attributes of ogi processed from maize has been reported [39]. However,non-significant differences ($p<0.05$) in all the parameters evaluated in this study could be attributed to the fact that they were produced from the same substrate.

3.0 Conclusion

Consumption of *agidi* sample with adequate nutritive value might promote the healthy status of individual. Preparation of *agidi*in a hygienic environment will reduce the risk of contamination to source of food pathogen. Therefore good storage method by preserving the raw *ogi* samples in polyethylene bag or air tight plastics should be encouraged by the hawkers.

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