



Effect of Fermentation on Bacteriological and Physicochemical Properties of ‘Ofada’ Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice (*Oryza sativa*) is an important annual crop in Nigeria. It is one of the major staples, which can provide a nation's population with the required food security of 2,400 calories per person per day. In Nigeria rice is one of the few food items whose consumption has no cultural, religious, ethnic or geographical boundary. Fermented rice is used to produce rice wine, spaghetti and noodles. Work was then carried out on the Nigerian rice var. ITA 150 (ofada) to determine the bacteriological and physicochemical activities during fermentation. Standard microbiological and chemical methods were used. Six microorganisms were isolated which include; *Bacillus cereus*, *Micrococcus luteus*, *Lactobacillus plantarum*, *Staphylococcus aureus*, *Leuconcostoc mesenteroides*, and *Bacillus licheniformis*. It was observed that the microbial loads increased till the 72nd hours of fermentation except *Staphylococcus aureus* and *Micrococcus luteus* that their loads decreased after the 72nd hours. There was an increase in the moisture, fibre, fat and protein contents, while carbohydrate, ash and anti-nutrients contents decreased. It was evident that fermentation process contributes to the bacteriological and physicochemical properties of the fermented rice in the production of another consumable product like rice wine, kunnu –zaki, spaghetti and the noodles.

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1. INTRODUCTION

Oryza sativa (var. ITA 150) commonly called 'Ofada' in Nigeria, is one of the indigenous rice varieties emanated from South-West Nigeria. It is unpolished medium grain rice. Consumers gave it preference for its unique taste and aroma. However, inefficient processing technology leads to unappealing products because of the presence of stones when it is being eaten [1].

"Rice is fermented to produce rice wine. Rice wine is an alcoholic beverage made from rice. Unlike the European wine, it is made by fermentation of natural sweet grapes and other fruits, rice wine are made from the fermentation of rice starch converted to sugars. The process is akin to that used to produce beer. Beer production employs a mashing process to convert starch to sugars whereas rice wine uses the amylolytic process" [2]. "Sake is often referred to in English – speaking countries as rice wine. It is produced by means of a brewing process using a mash, similar to that which is used for beer production. Thus, sake would be more accurately referred to as rice beer rather than rice wine. Rice wine typically has a higher alcohol content, 18% - 25% ABV, than grape wine (9%-16%) which in turn has a higher alcohol content than beer (usually 4%-6%). Rice wine is much used in Chinese cuisine and in other Asian countries. Alcoholic beverages distilled from rice were formerly exclusive in East and Southeast Asia countries. Later, knowledge of the distillation process reached India and Parts of South Asia through trade. Some types of rice wine are: Pangasi – Rice wine from Mindanao in the Philippines and Raksi - Tibetan and Nepali rice wine" [3].

In Nigeria, rice can be used in the production of "kunu-zaki", a beverage usually consumed in the Northern part of Nigeria. Kunu-zaki, known for its moderately high carbohydrate content, sweet taste and low viscosity, is produced mainly from millet (*Pennisetum* species), although sorghum (*Sorghum bicolor*), maize (*Zea mays*), rice (*Oryza sativa*) and other cereals can be used. It is normally flavored with a combination of spices commonly called "Kayan yaji" which includes ginger (*Zingiber officinale*), cloves (*Eugenia aromatica*), black pepper (*Piper guinese*) and cinnamon (*Xylopiacthiopica*) [4,5].

During fermentation, each microorganism contributes its quota by producing different enzyme which can act on the microbiological or physicochemical composition of the food either positively or negatively. Since the food products from the fermented rice is going to be consumed along with the fermenting microorganisms and also the physicochemical properties of the rice must have changed during fermentation, then there is need to determine the types of microorganisms and the physicochemical properties of the food to be consumed. This is necessary in case it contains pathogenic microorganisms that can cause food borne diseases. Therefore, the rationale behind this work was to see the effect of fermentation on microbiological and physicochemical properties of "ofada" rice. The specific objectives of this research work are to:

- (a). Determine the types and loads of bacteria associated with the fermented Nigerian rice (*Oryza Sativa* (ofada) Var. ITA 150);
- (b). Investigate the effect of fermentation on the physicochemical properties of the fermented rice.

2. MATERIALS AND METHODS

2.1 Sample Collection, Sterilization of Materials and Media Preparation

Three cups of "ofada" rice were bought in Igbemo Ekiti where the rice is being cultivated in large quantity. The inoculating chamber was sterilized using UV- light, all the glass wares used were sterilized inside the oven at 160°C for 1hour. The Nutrient agar (NA) and Nutrient Broth (NB) media were used for the isolation of bacteria. The culture media were prepared according to manufacturer's instructions. The media were then autoclaved at 121°C for 15 minutes.

2.2 Preparation of Rice Samples for Microbial Analysis

One gram of the rice was weighed into 9 mL of sterile water; the whole content was mixed properly. This constituted the stock solution. A syringe was used to dispense 9.0 mL of distilled water into each of four test tubes and the test-tubes autoclaved at 121°C for 15 minutes. One mL was transferred from the stock

solution of raw rice to a test tube containing 9.0 mL sterile distilled water and it was labelled as 10^{-1} . The serial dilution process was carried out serially until it got to the test tube labelled as 10^{-4} .

2.3 Isolation of Bacteria

From 10^{-4} of the serially diluted sample above, 0.5 mL was transferred to the center of a sterile Petri dish. About 15 mL of each molten NA cooled to 45°C was then added to each plate and rocked gently to facilitate mixing the agar with the sample. The NA plates were placed at 37°C for 24 hours.

2.4 Determination of Microbial Population and Cultural Morphology

The distinct bacterial colonies that grew on the NA were counted using colony counter and examined physically for their characteristics features: colour, shape, size, elevation, surface and edges.

2.5 Purification of Bacterial Isolates

The bacteria isolated were purified by streaking each type of the colonies onto fresh nutrient agar using inoculating loop and flame. The plates were incubated at 37°C about overnight. Gram staining was carried out and observed under the microscope for purity. The purified isolates were then placed on agar slants. Slants were incubated at 37°C for 24 hours and kept in the fridge until required for further tests.

2.6 Biochemical Characterization of Bacterial Isolates

Gram's staining, Motility test, Catalase test, Spore test, Fermentation of sugars and coagulase test were done according to standard microbiological methods.

2.7 Preparation of the Microbial Inoculum for Fermentation of Rice

Three loopfuls of microbial cells were taken with an inoculating loop from each stock of the purified isolates in to the sterile and cooled 10mL nutrient broth. It was incubated at 37°C for 24 hours. After 24 hours of incubation, 10 ml of each grown microorganism was centrifuged at 1, 500 rpm for 15 minutes and the supernatant was discarded. The cells were washed with 10 mL

sterile distilled water and re-suspended in another 10 mL sterile distilled water. This was used as bacterial inoculum preparation. A 5 mL was withdrawn and 15 mL of water was added to 10g of the raw rice and mixed together. In this way bacteria inoculum was prepared. The inoculum was done by using only one microbial type for fermentation. Fermentation was allowed to take place for 3 days (72 hours) at room temperature of $28 \pm 2^{\circ}\text{C}$. The Control was allowed to ferment naturally without inoculation. Sampling was done at 24 hours interval to determine the microbial loads.

2.8 Physicochemical Properties of the Fermented Rice

Physicochemical properties like moisture, fat, ash, carbohydrate, and fibre content of the fermented rice was determined according to the methods of AOAC, 2000.

2.9 Determination of Moisture Content

Each rice sample (2 g) was weighed into a pre weighed clean crucible and transferred into an oven set at 105°C for 24 hours. After which the crucible was transferred into a dessicator, cooled for 10 minutes and weighed. The crucible containing the sample were oven dried for 2 hours, cooled in the dessicator and reweighed. The drying, cooling and weighing processes were repeated until a constant weight was obtained. Moisture content was then calculated using the formula written below:
Weight of empty crucible = W0

Weight of the sample used plus crucible = W1 + W0

Weight of crucible plus oven dried sample = W3

Moisture content (%) (w/w) = $\frac{W1-W3}{W1-W0} \times 100/1$

2.10 Determination of Ash Content

Ash content is a measure of the total amount of minerals that are present in a food. It was quantified by weighing 2 g of the dried sample into a crucible, transferred into a muffle furnace set at 550°C and left for 4 hour to turn the same sample to white ash. The crucible and its contents were cooled in a dessicator and reweighed (AOAC, 2000). The percentage ash was calculated using this formula:

Ash content (%) (w/w) = weight of the ash / original weight of the sample x 100 / 1

2.11 Determination of Fat Content

The sample (1.0 g) was weighed into fat free extraction thimble and plugged tightly with cotton wool. The thimble was placed in an extractor, fitted up with reflux condenser. The heater was put on for six hours while constantly running tap water to condense the ether vapour. The ether was left to siphon over several times, at least for 12 times until it was short of siphoning. It was then noticed that any ether left in the extractor was carefully drained into the ether stock bottle. The thimble The extractor flask with the condenser were replaced and the distillation continued until the flask was practically dried (AOAC, 1990).

Percentage fat was obtained with the following formula.

Initial weight of dry soxhlet flask = W0

Final weight of oven dried flask + fat = W1

Percentage fat = $(W1 - W0) / \text{Weight of sample taken} \times 100 / 1$

2.12 Determination of Crude Protein Concentration

Protein content of each rice sample was calculated by using Micro Kjeldahl method (AOAC, 1990)

% protein = F x %N, where F = 6.25

2.13 Crude Fiber Determination

The method used in crude fiber determination was as described by AOAC [6]. Exactly 3 g of sample previously finely ground was weighed into a round bottom flask. A 100 mL of 0.5M H₂SO₄ solution was added to the mixture and boiled under reflux for 30 minutes, filtered under suction, washed severally with hot water until it was acid free. 100 mL of hot NaOH was added and boiled under reflux for 30 minutes and filtered under suction. The insoluble residue was dried into a constant weight in the oven at 100°C, cooled in a desiccator and weighed (W1). The weighed sample was incinerated in the muffle furnace at 550°C

for 1 hour, cooled in the desiccator and weighed (W2).

Calculation:

The loss in weight due to incineration was W1 - W2

$$\% \text{ Crude fiber} = \frac{W1 - W2}{\text{Weight of the sample}} \times 100$$

2.14 Determination of Carbohydrate Content

Anthrone method was used. The principle of this method is based on the fact that carbohydrates were first hydrolysed into simple sugars using dilute HCl.

Calculation:

Amount of carbohydrate present in 50 mg of the sample = mg of glucose/ volume of test sample x 100/1

3. RESULTS AND DISCUSSION

A total of 6 different bacterial types were observed in the fermented rice as inherent microorganisms, with varied microbial load. After assessing the microbiological parameters like color, surface, shape and elevation on nutrient agar and their Gram staining reactions with biochemical tests, *Bacillus cereus*, *Bacillus licheniformis*, *Leuconostoc mesenteroides*, *Lactobacillus plantarum*, *Micrococcus luteus* and *Staphylococcus aureus* were the inherent organisms on the ofada rice. The highest colony forming unit bacteria (highest occurred organism) observed was *Staphylococcus aureus* (6.8×10^4 cfu/g) and least was *Bacillus cereus* (2.2×10^4 cfu/g) as seen in Fig. 1. The population of *Bacillus cereus*, *Bacillus licheniformis*, *Lactobacillus plantarum* and *Leuconostoc mesenteroides* increased from 24 hours till 72 hours of fermentation. However, *Staphylococcus aureus* and *Micrococcus luteus* showed a reduction in population after 72 hours of fermentation (Fig. 2). The isolated bacteria were similar to the findings of [7] who reported the isolation of these bacteria during the fermentation of a Nigerian rice var "ofada". However, Odunfa, [8] first reported that the predominant fermentation bacteria during maize fermentation in the production of 'ogi' were *Bacillus subtilis* and *Lactobacillus plantarum*. The reduction in *Staphylococcus aureus* colony count after the 72 hours of fermentation could be due

to decrease in pH, [9,10] reported that pH reduced gradually as the fermentation progressed, which only allows acidophiles (acidic microorganisms) to grow, hence reduction in Staphylococcal count and increase in *Lactobacillus* sp count. Also, *Staphylococcus aureus* needs salt before it can grow well. Reduction in the amount of available nutrients needed for their growth and release of toxic substances by some microorganisms into the fermenting substrate could have adverse effect on other (microorganism) which can thereby lead to their reduction, as supported by Gaggia et al. [11] who worked on the fermentation of *Hura crepitans* seeds. A significant differences were observed in each of the fermented samples at $p \leq 0.05$ % confidence interval. There was an increase in the moisture, protein and fibre contents of the fermented rice sample within the 72 hours of fermentation. However contents of Ash, Fat and carbohydrates decreased as shown in Fig. 3. This was similar to the report given by Eka, [12] who reported decrease in fat content of locust beans after fermentation. The reduction in the crude fat content of the fermented grains may be due to the activities of microorganisms, which led to the breakdown of some amino acids with liberation of ammonia [13] or leach out of the fat and other metabolic activities that occurred during the fermentation.

After the third day (72 hour) the protein content increased. This may be due to the fact that some microorganisms were dead and released their constituents into the rice samples which could have increased the protein concentration as suggested by Abu et al. [14]. The biomass could equally have contributed to the increased protein content [15,16].

The carbohydrate contents decreased, the decrease was obviously due to the fact that the carbohydrates were used up as sources of energy by the metabolizing microbes during fermentation and those microorganisms were not photosynthetic bacteria. Uzomah and Ogunsanya [17] worked on *Mucuna sloanei*, *Detarium microcarpum* and *Brachystegia euccycoma* and found out that the carbohydrate contents of each of them decreased till the 3rd day of fermentation, Since, fermentation process involves the conversion of materials to the peculiar substances needed by the microorganisms for various activities, like build up cell wall.

Reduction in the ash content of all the samples may be due to boiling loss and leaching of the soluble inorganic salt during fermentation [18,19].

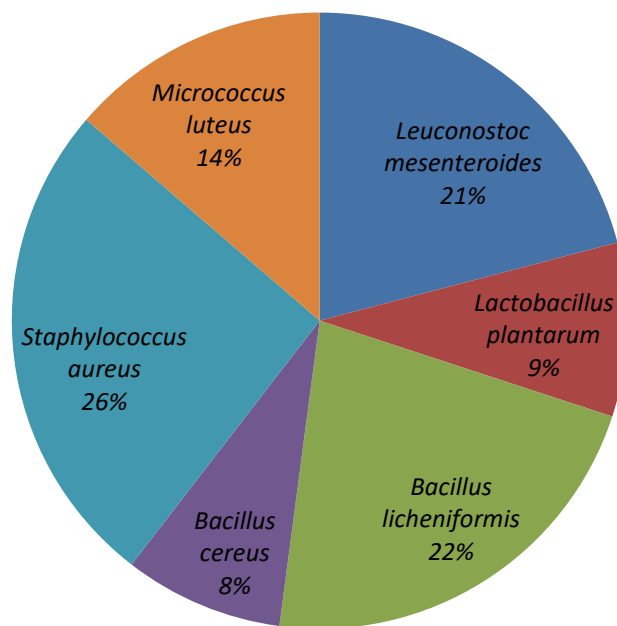


Fig. 1. Occurrence of bacteria population before fermentation

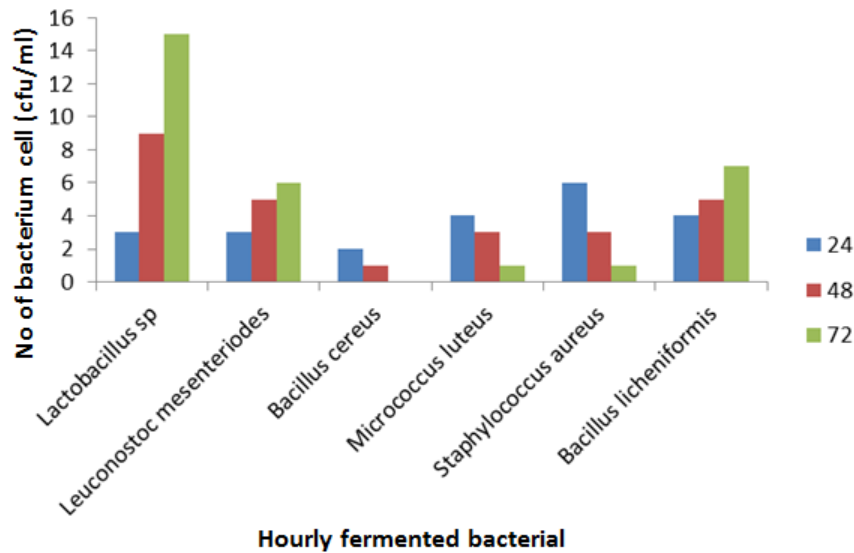


Fig. 2. Microbial loads of the fermenting rice hourly

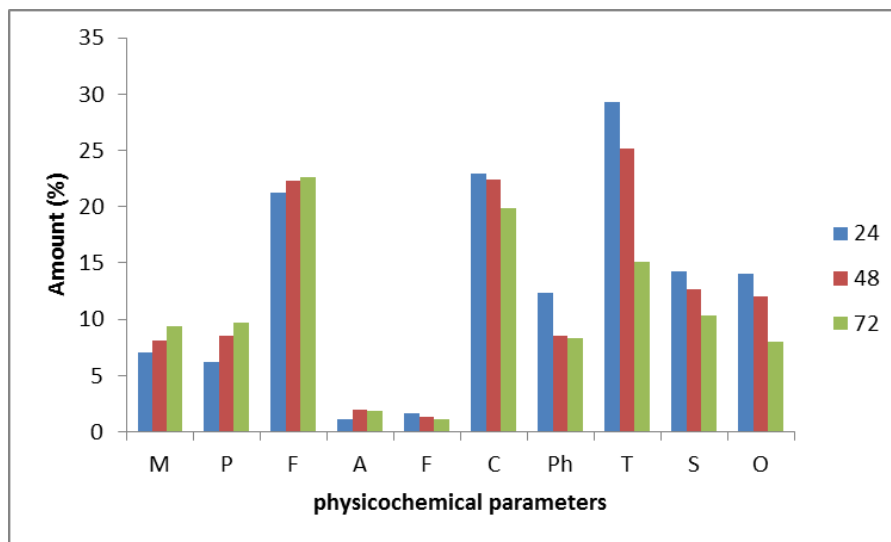


Fig. 3. Percentage physicochemical parameters during fermentation

Key: M: moisture content, P: Protein content, F: Fibre content, A: Ash content, F: Fat content, C: Carbohydrate content, Ph: Phytate content, T: Tannin content, s: Saponin content, O: Oxalate content

4. CONCLUSION

It can be concluded that every food product has its own resident microflora and they contribute to the fermentation process. From the results of this study, fermentation process produced significant and noticeable effect on the microbial load of the fermented Nigerian 'ofada' rice samples by increasing some microorganism like *Lactobacillus* sp, a probiotic and decreasing some like *Staphylococcus aureus* which can cause staphylococcal food poisoning. Also, fermentation increased the fibre

contents of the rice, which is beneficial to the body. Whenever, fermented rice product is consumed, it can be of good value to the body without posing any disease. Fermentation of this variety of rice can be acceptable in order to produce a fermentable food product, since its originality is still retained because it has not gone through any pre-treatment before fermentation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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