Effects of Fermentation Period on some Quality Attributes of Pearl Millet Chin-Chin

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Received: 17-OCT-2023; Reviewed: 19-MARCH-2024; Accepted: 10-APRIL-2024
https://dx.doi.org/10.4314/fuoyejet.v9i3.1

ORIGINAL RESEARCH

Abstract— This study was conducted to evaluate the quality of chinchin made from fermented pearl millet grain flour. Pearl millet grains were fermented for different periods (0, 12, 24, 36, 48 and 60 hours), dried and milled into flour. The pearl millet flour was thereafter, combined with other ingredients and processed into chinchin. The proximate composition, texture profile, anti-nutrient content (phytate) and sensory evaluation of the chinchin were determined. There were significant differences (P<0.05) in the proximate composition of the chinchin samples with values ranging from 9.07-9.79%, 17.51-18.58%, 8.95-9.93%, 1.75-1.91%, 4.94-6.10%, 1.85-1.90% and 58.00-60.30% for moisture, protein, fat, ash, crude fibre and carbohydrate contents respectively. There was significant difference (P<0.05) in texture profile with the hardness values ranging from 134.14N-220.88N, a significant difference (P<0.05) in phytate content with values ranging from 0.0019(mg/g) - 0.00825 (mg/g). There was also significant difference (P<0.05) in sensory attributes of the chinchin samples parameter measured. The study concluded that chinchin of acceptable quality comparable to the 100% wheat flour chinchin are obtainable from fermented millet flour grain up to 24 hours pearl millet grain fermentation.

Keywords— Chinchin, Fermentation, Pearl Millet, Proximate, Texture profile Analysis.

1 INTRODUCTION

Cereal grains are the major source of calories and proteins for the people of Nigeria. The major cereals cultivated in Nigeria are sorghum, millet, rice and maize (Nkama & Gbenyi, 2001). Millets are amazing in their nutritional content. They are three to five times nutritionally superior to the widely promoted rice and wheat in terms of proteins, minerals and vitamins. Some authors have studied its viability in bakery products such as breads, biscuits and pasta (Schoenlechner *et al*., 2013), aiming to replace whole-wheat flour with millet flour. The acceptability of the foods developed with millet flour, such as biscuit, dough and breads, is reported to be very good. (Saha *et al*., 2011; Schoenlechner *et al*., 2013).

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SECTION A- AGRICULTURAL ENGINEERING & RELATED SCIENCES
Can be cited as:
Agbaje M. T., Adegoke A. A, Olaniyi P., Obadina O. A, Omisanya O. K., Ogunniyi A. Q. and Tejumade O. A. (2024). Effects of Fermentation Period on some Quality Attributes of Pearl Millet Chin-Chin. FUOYE Journal of Engineering and Technology (FUOYEJET), **9(3), 370-377.**
https://dx.doi.org/10.4314/fuoyejet.v9i3.1

Pearl millet (*Pennisetum glaucum*) is an underutilized crop widely grown for food and non-food uses. It is a versatile millet mainly used in traditional food preparations and has considerable potential as a novel food ingredient (Basavaraj *et al*., 2010). Although cereal grains constitute a major source of dietary nutrients worldwide, they are deficient in some basic components (e.g Essential amino acids). Fermentation may be the simplest and most economical way of improving their nutritional value, sensory properties and functional qualities (Taylor *et al*., 2010).

Fermented food products are notable all around the world and are sometimes categorized as "functional foods'' due to their purported health benefits (Adebiyi *et al*., 2018; Adebo, 2020). Fermentation brings about a "pre-digestion" of food substrates to make the associated nutrients more bioavailable and, in some instances, removing allergens, antinutritional compounds (such as phytate) and toxins (such as cyanogenic glycosides, bacterial toxins, mycotoxins, biogenic amines) (Samtiya, 2021). Fermentation is also well-known to improve the sensory properties of food through imparting unique flavours, textures and aromas, preserve food products as well as to enhance the economic value (Hlangwani *et al.*, 2020).

Previous studies have been carried out on the effect of fermentation time on the nutritional composition of various food products. A decrease in the ash and fibre content, and an increase in the protein and crude fat content was observed for maize and African locust beans as the duration of fermentation increased (Agblemanyo & Abrokwa, 2019). Amro *et al.*, (2006) observed that fermenting germinated grains increased the protein digestibility of pearl millet cultivars and increased the Vitamin C content in a complementary flour (Feyera *et al*., 2020). Also, a lowered pH value and a reduced tannin and phytate content were observed in a sorghum-pearl millet cereal (Onyango *et al.,* 2013).

Chin-chin is a fried snack popular in West Africa. It is a sweet, hard, donut- like baked or fried dough of wheat flour, eggs and other customary baking items (Akubor, 2004). It is easily one of the most favoured food items, a much-relished African pastry which could serve as a dessert, snack and also as a popular street food. In Nigeria and throughout the world, snacks foods are widely spread and eaten among kids and adults because of their convenience both in preparation and circulation and also because of their distinctive taste.

Encouraging the consumption of fermented pearl millet chinchin could improve the acceptability of fermented millet food product in the form of snacks, mostly among children and young adults. This could help improve diets, prevent occurrence of celiac diseases and also increase the market value of millet grains in Nigeria.

This study was carried out to evaluate the effect of fermentation periods on some of the attributes of fermented pearl millet chin-chin.

2 Materials And Method

Materials used (Pearl millet grains, margarine, sugar, eggs etc.) were purchased at a local market in Abeokuta, Ogun state, Nigeria. The production was carried out in the Food processing laboratory at the Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria.

2.1 Fermentation Of Pearl Millet Grains

The method described by Onweluzo & Nwabugwu (2009), with a slight modification was used. Pearl millet (*Pennisetum glaucum*) grains were sorted and cleaned and unwanted particles removed. The grains were transferred to a transparent bowl, distilled water was added and the bowl was covered tightly for the fermentation process to occur. The grains were steeped in water for various time intervals ranging from 0 to 60 hours. (1:3 w/v ratios of seeds to the volume of steeping water) and dried at 70^{o}C for 4 h in hot air oven and allowed to cool. The samples were then labelled accordingly.

2.2 Pearl Millet Flour Production

Pearl millet was processed into flour using an adapted method described by Poongodi & Jemima (2009). The dried pearl millet grains were milled using a single flour milling machine. The flour was sifted, then packed in impermeable polyethylene bags and kept in enclosed plastic buckets for storage.

2.3 Chin-Chin Preparation

Chinchin was produced using a modified method outlined by Akubor (2004) with little modifications.

2.4 Evaluation Of The Proximate Composition

Protein, fat, minerals, crude fibre and moisture content were determined by the methods of Analysis of the Association of Official Analytical Chemists (A.O.A.C., 2010).

2.5 Texture Analysis

The texture measurements of the pearl millet chinchin was evaluated using a TA.XT.plus Texture Analyzer (Stable Microsystems, Godalming, UK) provided with Texture expert software.

2.6 Anti-Nutrient Content (Phytate)

The method described by Inuwa et al., (2011) was used for phytate determination.

2.7 Sensory Evaluation

The millet chin chin was subjected to sensory evaluation using 20 panellists selected randomly from the department of Food science and Technology, Federal University of Agriculture Abeokuta. The samples were evaluated using the nine-point hedonic scale, where 9 represents "like extremely" and 1 represents "dislike extremely". The attributes assessed includes colour, taste, flavour, texture, appearance, crispness and overall acceptability (Larmond, 1991).

2.8 Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using SPSS (version 20). Duncan multiple range test was used to separate the differences in the mean scores.

3 Results And Discussion

3.1 Proximate Composition Of Fermented Pearl Millet Chinchin

Table 1 shows the proximate composition of the chinchin samples. The moisture content values obtained, 9.07-9.79%, were within the range reported to have no adverse effect on the shelf life of a food product.

Protein content increased as fermentation increased with values ranging from 18.02% - 18.58% for the fermented samples, with significant differences (P<0.05) between the samples. The control (100W) had the lowest value at 17.51% while $100M^{60}$ had the highest value. Kumari *et al*. (2022) similarly observed an increased crude protein content in fermented pearl millet flour at 28°C for 3 days. Fermentation has been found to increase the protein and amino acid content (Cui et al., 2012) of food due to the hydrolysis of complex proteins to simpler proteins (Gee & Narayanasamy, 2020).

Fats help to distribute ingredients throughout foods to give a deeper flavor, hence, fatty foods usually have a special mouthfeel (Drewnowski & Almiron-Roig, 2010). The fat content of the fermented samples was 9.52-9.93%, with $100M^{60}$ having the highest value. Studies have suggested that fermentation leads to an increase in fat content in pearl millet grains (Akinola et al., 2017). Furthermore, fat content of fried food increases due to absorption and retention of oil (Pokorny, 1998). Crude fibre content ranged from 1.85-1.91% and sample $100M^{0}$ had the highest value. Fibre promotes digestive health (Senthilkumar, 2020), lowers cholesterol and regulates blood sugar (Ogunlade et al., 2015). The carbohydrate content was between 58.00-58.88%, for the fermented samples, the highest being $100M^{0}$, while the control (100W) recorded a value of 60.30%. Kumari *et al*. (2022) also observed a decrease in the carbohydrate content and an increase in soluble sugars in fermented pearl millet. This is because during fermentation, carbohydrates in the grains gets degraded by microorganisms (Alexander et al., 2019).

Table 1. Effect of fermentation on proximate composition (%) of Pearl millet chinchin

Sample	Moisture Content	Crude Protein	Total Ash	Crude Fat	Crude Fibre	Carbohydrate
100W	9.64 ± 0.14^{a}	17.51 ± 0.14^{a}	1.75 ± 0.07^{a}	8.95 ± 0.17^{a}	1.85 ± 0.02^{a}	60.30 ± 0.27^{c}
$100M^{0}$	9.62 ± 0.52^{a}	18.16 ± 0.13^{b}	1.91 ± 0.00^{c}	9.52 ± 0.16^{b}	1.91 ± 0.01^{b}	58.88 ± 0.84^{ab}
$100M^{12}$	9.40 ± 0.23^{a}	18.09 ± 0.05^{b}	1.91 ± 0.01^{c}	9.65 ± 0.07^{b}	1.90 ± 0.01^{b}	59.05 ± 0.35^{ab}
$100M^{24}$	9.07 ± 0.01^{a}	18.02 ± 0.00^{ab}	1.80 ± 0.00^{ab}	9.64 ± 0.00^{b}	1.90 ± 0.00^{b}	58.50 ± 0.52^{bc}
$100M^{36}$	9.72 ± 0.86^{a}	18.44 ± 0.48^{bc}	1.85 ± 0.07^{bc}	9.60 ± 0.04^{b}	1.89 ± 0.02^{b}	58.64 ± 0.26^{ab}
$100M^{48}$	9.40 ± 0.39^{a}	18.58 ± 0.19^{c}	1.80 ± 0.00^{ab}	9.69 ± 0.38^{b}	1.89 ± 0.02^{b}	58.64 ± 0.26^{ab}
$100M^{60}$	9.79 ± 0.05^{a}	18.48 ± 0.02^{b}	1.90 ± 0.00^{c}	9.93 ± 0.23^{b}	1.90 ± 0.00^{b}	58.00 ± 0.79^{a}

Values are means of two replicates. Means in the same column with different superscript are significantly different (P<0.05).

100W = chin chin from 100% wheat flour (Control)

$100M^{0}$ = chin chin from 100% millet flour (No fermentation)

$100M^{12}$ = chin chin from 100% millet flour (12hours Fermentation)

$100M^{24}$ = chin chin from 100% millet flour (24hours Fermentation)

$100M^{36}$ = chin chin from 100% millet flour (36hours Fermentation)

$100M^{48}$ = chin chin from 100% millet flour (48hours Fermentation)

$100M^{60}$= chin chin from 100% millet flour (60hours Fermentation

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3.2 TEXTURE PROFILE ANALYSIS

Texture Profile Analysis (TPA) is a method used to evaluate the physical properties of food products. TPA is based on a double mechanical compression test to provide insight into how samples behave when chewed (Shin & Choi, 2021). The Table 2 illustrates the textural properties of pearl millet chinchin. Hardness refers to the force required to compress a food product to a given distance (Shin & Choi, 2021). It is an important textural parameter because it is related to the perception of firmness and chewiness in food products (Li et al., 2022). From Table 2, it was observed that the hardness of the chinchin decreases with increase in the fermentation period. Hong et al. (2022) also reported a decrease in the hardness of wheat starch gel caused by Bifidobacteria fermentation. The values obtained ranged from 220.80-134.14N. Sample 100M^0 had the highest value while 100M^{60} recorded the lowest value.

Cohesiveness is a measure of how well a food retains its form between the first and second chew. It is an essential parameter in swallowing, and it is of particular interest for people suffering from dysphagia (Tobin et al., 2017). The cohesiveness value ranged from 0.004 to 0.0225 and 100M^0 had the highest value.

The value obtained for Fracturability ranged from 31.54 (100M^0) to 107.55 (100M^{60}) N which is higher than the values reported by Obomeghei and Ebabhamiegbebho (2020). The value obtained for fracturability of the chinchin samples were between 22.04 and 71.97. Fracturability is a textural property of food that refers to its tendency to crack, shatter, or fail upon the application of a relatively small amount of force or impact and it is a desirable textural property in chinchin. (Duan et al., 2014).

Stringiness refers to the ability of a food to stretch or form strings when pulled apart (Alaei et al., 2018). The values obtained for stringiness in the fermented sample were from 3.63-3.75 mm. 100M^0 had the highest and 100M^{60} had the lowest value. Gumminess values were between 0.534 and 5.631N and 100M^0 had the highest value. Gumminess is not generally considered a desirable characteristic in fried products, instead, a crispy and crunchy texture is preferred (Voong et al., 2019).

Table 2. Effect of Fermentation on Textural Properties of Pearl Millet Chinchin

Sample	Hardness (N)	Cohesiveness	Fracturability (N)	Gumminess (N)	Stringiness (mm)
100W	168.88±3.07^a	0.0225±0.004^{ab}	114.81±30.9^b	3.083±0.42^{ab}	3.76±0.09^a
100M^0	220.88±27.2^a	0.0225±0.007^b	31.54±24.9^a	5.631±0.87^b	3.75±0.03^a
100M^{12}	181.04±43.9^a	0.012±0.006^{ab}	86.43±13.7^a	2.068±0.39^a	3.72±0.07^a
100M^{24}	177.68±28.7^a	0.004±0.006^a	54.45±4.2^{ab}	0.534±0.72^a	3.69±0.17^a
100M^{36}	160.01±47.0^a	0.0165±0.014^{ab}	52.46±8.3^{ab}	2.514±1.91^a	3.68±0.07^a
100M^{48}	151.34±21.8^a	0.0165±0.009^{ab}	49.43±28.2^{ab}	3.083±1.97^{ab}	3.65±0.03^a
100M^{60}	134.14±47.8^a	0.017±0.006^{ab}	107.55±39.7^{bc}	2.122±0.06^a	3.63±0.20^a

Values are means of two replicates. Means in the same column with different superscript are significantly different (P<0.05).

100W = chin chin from 100% wheat flour (Control)

100M^0 = chin chin from 100% millet flour (No fermentation)

100M^{12} = chin chin from 100% millet flour (12hours Fermentation)

100M^{24} = chin chin from 100% millet flour (24hours Fermentation)

100M^{36} = chin chin from 100% millet flour (36hours Fermentation)

100M^{48} = chin chin from 100% millet flour (48hours Fermentation)

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$100M^{60}$ = chin chin from 100% millet flour (60hours Fermentation)

Table 3. Effect of fermentation on Sensory properties of Pearl millet chinchin

Sample	Appearance	Colour	Texture	Flavor	Crispiness	Taste	Overall Acceptance
100W	8.15 ± 0.59^{f}	8.00 ± 0.56^{f}	8.50 ± 0.76^{e}	8.00 ± 0.32^{f}	8.50 ± 0.51^{e}	8.05 ± 0.51^{d}	8.35 ± 0.49^{f}
$100M^{0}$	7.00 ± 0.65^{e}	6.55 ± 0.69^{e}	7.70 ± 0.47^{d}	7.60 ± 0.69^{c}	8.20 ± 0.52^{e}	7.60 ± 0.50^{c}	7.60 ± 0.50^{e}
$100M^{12}$	6.00 ± 0.73^{d}	5.75 ± 0.44^{c}	6.95 ± 0.51^{c}	7.60 ± 0.50^{c}	7.45 ± 0.51^{d}	7.50 ± 0.69^{c}	6.95 ± 0.60^{d}
$100M^{24}$	6.85 ± 0.37^{e}	6.45 ± 0.76^{e}	6.85 ± 1.04^{c}	8.00 ± 0.65^{d}	8.20 ± 0.77^{e}	7.75 ± 0.55^{cd}	7.70 ± 0.47^{e}
$100M^{36}$	5.15 ± 0.67^{b}	5.00 ± 0.56^{b}	5.90 ± 0.64^{b}	6.90 ± 0.55^{b}	6.50 ± 0.60^{c}	6.95 ± 0.61^{b}	6.35 ± 0.67^{c}
$100M^{48}$	5.60 ± 0.50^{c}	5.00 ± 0.65^{b}	5.55 ± 0.51^{ab}	6.90 ± 0.64^{b}	5.70 ± 0.57^{b}	5.95 ± 0.61^{a}	5.50 ± 0.51^{b}
$100M^{60}$	4.00 ± 0.73^{a}	4.00 ± 0.56^{a}	5.15 ± 0.59^{a}	5.85 ± 0.59^{a}	4.35 ± 0.75^{a}	5.80 ± 0.83^{a}	4.35 ± 0.74^{a}

Values are means of two replicates. Means in the same column with different superscript are significantly different ($P<0.05$).

3.3 Effect Of Fermentation On %Phytate Content Of Pearl Millet Chinchin

Antinutritional factors reduces the bio-accessibility of nutrients such as minerals, protein etc.; and the most significant antinutrient compound in pearl millet is phytate (Sheethal et al., 2022). The levels of phytate content observed in the fermented samples as shown in figure 1 were very low ranging from 0.00825-0.0019 mg/g. The lowest value of phytate was attained at the 60h (0.0018mg/g). The observed decrease in phytate content with increase in fermentation periods were as a result of the activities of phytase during fermentation. According to Jianfen et al. (2008), fermentation was the most effective method for decreasing phytic acid by up to 95% in brown rice. Similarly, Sokrab et al. (2014) concluded that fermentation has a significant effect on the phytate content of food. He observed a significant decrease in phytic acid and polyphenols contents of corn fermented for 14 days. The reduction of phytic content in naturally fermented millet flour at 20, 25, and 30°C for 72 hours was also reported by Kheterpaul & Chauhan (1991), likewise Kumari et al. (2022).

3.4 Sensory Properties Of Pearl Millet Chinchin

The result of the sensory evaluation of pearl millet chin-chin are shown in Table 3. Semi-trained panelists were given a hedonic scale questionnaire to evaluate the sensory characteristics of the chinchin using a 9 points scale. Pearl millet was evaluated for appearance, colour, texture, flavour, crunchiness, taste and overall acceptance. There were significant differences (P<0.05) in all the attributes measured. Generally, sample 100W recorded the highest score for all parameters assessed. No apparent trend was observed for the overall acceptability, flavour and crispiness for all samples. But, a decrease in the values for the appearance, colour, texture and taste were observed as the fermentation period increased.

Sample 100W had the highest likeness in terms of taste and flavour with values of 8.00 and 8.05 respectively, while sample $100M^{60}$ had the lowest values of 5.85 and 5.80 in term of taste and flavour respectively. The texture value ranged from 8.50-5.15, sample 100W had the highest value for likeness at 8.50 while $100M^{60}$ sample had the lowest value of likeness in terms of texture. In terms of overall acceptability, 100W chinchin sample had the highest value of likeness with 8.35, while sample $100M^{60}$ had the lowest value at 4.35.

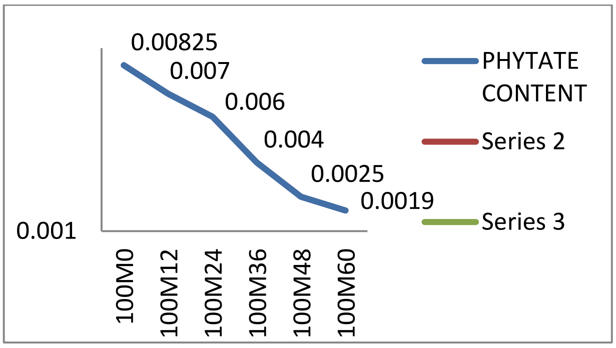

Fig. 1. Effect of Fermentation on %Phytate content of Pearl Millet Chinchin

Values are means of two replicates. Means in the same column with different superscript are significantly different (P<0.05).

4. Conclusion

From the results obtained, it is evident that fermentation, though an ancient food processing technique, remains an important approach for enhancing nutritional composition and bioavailability of nutrients. It was observed that fermentation increased the protein, fat, dietary fibre and ash content of chinchin; enhanced the taste and aroma of the chinchin samples. However, the chinchin samples became softer and the colour darker as the fermentation progressed which generally affected the sensory acceptability after a 24-hour period. The anti-nutrient (phytate) content of the chinchin was also observed to decrease significantly as fermentation increased.

In Nigeria, snacks are widely spread and eaten primarily for pleasure. Implementing fermented millet chinchin as part of the diet may help prevent diabetes, obesity, celiac disease and improve nutrition, and commercial production of fermented millet sorghum will provide additional socioeconomic benefits.

Despite its high nutritional value compared to other cereals, pearl millet is still an under-utilized crop in Nigeria. Hence, in order to fully exploit the benefits and acceptability of fermented millet chinchin, more research should be conducted, particularly focusing on the colour attributes and texture profile properties. Storage studies should also be conducted on the finished product to determine the shelf stability of the snack.

http://dx.doi.org/10.46792/fuoyejet.v9i3.1 engineering.fuoye.edu.ng/journal

ACKNOWLEDGMENT

Authors will like to acknowledge the contribution of the technical staff in the Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria.

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