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Effect of Drying Techniques of Moringa Leaf on the Quality of Chin-Chin Enriched with Moringa Leaf Powder

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Abstract: *Moringa oleifera leaf powder was processed using oven, sun and shade drying techniques to study the effect of drying on the proximate and mineral properties. Chin-chin was enriched with 1% dried Moringa leaf (DML) powder samples. Chin-chin without Moringa enrichment was equally produced and used as the control sample. Proximate analysis of the DML powder samples showed that oven drying technique effectively decrease the moisture and fat contents of the powder to 1.65% and 9.12%, respectively and increased the fibre value to 6.34%. The highest protein value (32.14%) was observed on the sun dried sample and there was significant difference ($p<0.05$) in all the DML powder samples. Mineral content of the DML powder showed that there was no significant effect ($p<0.05$) in the magnesium content of the samples while there was in the calcium, iron and zinc contents. Oven dried sample had the highest calcium (190.5mg/100g), sun dried highest zinc (7.1mg/100g) and shade dried highest iron content of 51.3mg/100g. Proximate composition of the produced chin-chin samples showed that shade dried had significantly lower moisture (2.5%), highest protein (11.21%) and fibre (2.56%) compared to other chin-chin samples. Apart from ash content of the chin-chin samples, a significant effect was observed in all the proximate composition of the products. Sensory evaluation of the DML powder enriched chin-chin showed that there was no significant effect in all the sensory attributes analysed. Control chin-chin sample (A) had significantly higher likeness in all the organoleptic attributes. For the fact that general acceptability score of Moringa enriched chin-chin ranged between 7.1 – 7.2 on a 9 point hedonic scale, is an indication that they were equally accepted by the panelists.*

Keywords: *Moringa leaves, Drying techniques, Wheat flour, Enriched chin-chin, Quality assessment*

I. Introduction

Deep fried foods have a satisfying crunchy texture and a distinctive taste which are widely enjoyed. Many dishes cooked by this method are quite inexpensive and so popular in low budget outlets. Also, most snacks are products from deep frying process. In Nigeria and throughout the world, snack foods are widely spread and eaten among kids and adults rather than vegetables because of their convenience both in preparation, circulation and also because of their distinctive taste. Matz [1] defined snack foods as being something consumed primarily for pleasure not used in a regular meal or for social habits. Chin-chin is a traditional Nigerian snack prepared using wheat flour, butter, milk and eggs made from a stiff paste, deep fried until golden brown and crisp. It is quite popular across Nigeria and most part of Western Africa. It has a sweet taste, slightly hard and may be equated to a harder version of doughnut. Occasionally, the chin-chin might even contain cowpeas and at times, it may be prepared by baking instead of frying [2]. Its nutritive value could also be enriched with some plant vegetables such as dried Moringa leaf powder.

Plant vegetables are important protective food and highly beneficial for the maintenance of health and prevention of diseases. Vegetables contain valuable food ingredients which can be successfully utilized to build up and repair the body tissues [3]. Vegetables are valuable in maintaining alkaline reserve in the body. They are valued mainly for their high vitamins and minerals. Vitamin A, B and C are contained in vegetables in fair amount. The major contributions of vegetables to human are vitamin A, ascorbic acid, as well as good amount of some minerals [4].

In Nigeria, malnutrition is on the increase due to poverty, low food production, low availability of macronutrient in foods, lack of proper food education and ignorance of cheap availability of vegetable such as Moringa olaifera plant. For a vegetable to combat malnutrition, it must comply with certain criteria such as accessibility, availability in the market, low cost, ease of cultivation and preparation. Beth and Lindsay [5] stated that Moringa oleifera might be a product that solves this problem of malnutrition in a lasting way as it has been reported to meet these criteria. Increase Moringa utilisation and consumption are critical to alleviate the incidence of nutritional deficiencies in Nigeria and world-wide. Scientific survey and investigations on some plants indicated that Moringa oleifera is one of the promising plants which could contribute to increased intake of some essential nutrients and health-promoting phytochemicals [6]. Moringa leaves are highly nutritious, they are significant source of beta-carotene, vitamin C, iron, potassium and protein. Its protein quality compares well with that of milk and eggs [7]. Emelike et al., [8] reported cookies fortified with 5% dried Moringa leaves and

equally observed its comparison. Rajangam et al., [9] reported that Moringa leaves may be regarded as a protein and calcium supplement. According to Akpapunam [10], the leaves of the Moringa oleifera tree have no parallel in the plant kingdom. It is the most nutritious in the world with most of its benefits stored in the small green leaves of this unassuming plant known as the "Tree of Life". Moringa contains more than 90 nutrients including 40 powerful antioxidants [7].

Based on the numerous nutrients and health benefits of Moringa, it is now gaining wide acceptance in Nigeria as a newly discovered plant vegetable [11]. Moringa is widely grown and cultivated in the Northern part of Nigeria where it is locally called "Zogeli" (among the Hausa speaking people). Moringa oleifera can be grown in a variety of soil conditions preferring well-drained sandy or loamy soil that is slightly alkaline [12]. It is considered as one of the world's most useful trees and almost every part of the tree can be used for food. The leaves especially young shoots are eaten as green in salads, vegetable curries and pickles. The leaves are considered to offer great potential for those who are nutritionally at risk of protein and calcium deficiency diseases [11]. Gaman and Shenngton [13] stated that Moringa leaves can be eaten fresh, cooked or stored as dried powder for many months without refrigeration.

Moringa leaves are highly perishable and they require processing treatment to prevent post-harvest losses. This implied that treatment such as drying preserves them from fast deterioration. Drying is a great way of preserving Moringa leaves and to reduce them into powder, making it easier to store and use at any time. Even if a large amount of water soluble vitamins are lost during drying and storage, the leaf powder still constitutes a very rich nutritional supplement which are concentrated in the dried leaves [14]. Enoh-Arthur and Damme [15] stated that using Moringa leaf powder is a way of preserving nutrients as the powder can be added to food after cooking. Makkar and Becker [16] reported that Moringa powder can be added to almost any food as a nutrient supplement. The nutritive values of pap, cereals and drinks can be improved using dried Moringa powder [7] and cookies can also be fortified with Moringa leaf powder [8].

Mbah et al., [11] and Adeyemi et al., [17] studied different drying methods on the proximate, phytochemical and other nutrient composition of the dried Moringa oleifera leaves. This research is therefore focused on the effect of drying techniques such as oven, sun and shade drying on the proximate and mineral composition of Moringa leaves. Produce chin-chin enriched with the dried Moringa leaf powder and to analyse its proximate and sensory properties.

II. Materials and Method

Fresh Moringa oleifera used in this study was harvested from Diplomat Farm and Services Ltd, Rivers State University of Science and Technology, Port Harcourt. Wheat flour, margarine, sugar, fresh eggs, milk, salt, flavours and sodium biacarbonate (baking powder) were purchased from Next-Time Supermarket in GRA Phase II, Port Harcourt, Nigeria.

2.1. Preparation of Moringa Leaf Samples

Moringa leaves were harvested from stem by hand, sorted and weighed with total weight of 1.2kg. This was further divided into three parts of 400g each for the three techniques of drying such as oven, sun and shade drying. Each part was washed under a running tap and poured into a basket to drip excess water. One part was oven dried at 50^{o}C for 12h, the next sample was sun dried by spreading two trays on a table under the sun consecutively for 5 days and the last sample was shade dried also by spreading two trays and placed on a high plane in the shade for 7 days in accordance to the method earlier reported by Emelike et al., [8]. All dried samples were milled with Philips Spice grinder, (model HR 1701/BC, U.K).

2.2. Formulation and Preparation of Chin-Chin

Chin-chin was prepared using the method outlined by Akubor [2] with modifications. Hundred grams (100g) of wheat flour was weighed and sieved using 250 micron particle size sieve into four different clean bowels labelled A, B, C and D. All dry ingredients such as Moringa powder, sugar, salt and baking powder were weighed and sieved into the bowls and mixed thoroughly to ensure uniformity. Margarine was rubbed-in, a mixture of egg and milk were turned in and mix to form dough. The dough was placed on a floured surface and kneaded until smooth and elastic. The kneaded dough was rolled out to approximately 2cm thick and then cut into small squares of about 2cm by 2cm in size. Vegetable oil (Corn oil) was put inside a deep fryer (1800 MC model, UK) and allowed to heat until the temperature of fryer reached 180^{o}C. Dough cubes were placed in the hot oil and the chin-chin was deep fried for 8min until golden brown. The fried chin-chin was removed and drains off excess oil, package and stored at room temperature (28 ± 2^{o}C) for analysis.

Table 1: Formulation Chin-Chin Samples

Ingredients	A	B	C	D
Wheat flour (g)	100	100	100	100
Moringa flour (g)	0	1	1	1
Margarine (g)	25	25	25	25
Sugar (g)	25	25	25	25
Egg (g)	23.9	23.9	23.9	23.9
Milk (g)	10	10	10	10
Baking powder (g)	5.6	5.6	5.6	5.6
Water (ml)	50	50	50	50

Key: A = Control, B = Oven dried, C = Sun dried, D = Shade dried samples

2.3. Proximate Evaluation

The dried Moringa leaf and chin-chin samples were analysed for moisture, ash, protein, fibre and fat using the Standard Assay method as described by AOAC [18]. Total carbohydrate was determined using the Anthrone reagent method in accordance to Osborne and Voogt [19].

2.4. Mineral Evaluation

Minerals such as magnesium, calcium, iron and zinc of the dried Moringa leaf samples were determined using Atomic Absorption Spectroscopy (Perkin Elmer, 2380) according to the method described by Egan et al., [20] with some modifications.

2.5. Sensory Evaluation

Sensory evaluation of the dried Moringa enriched chin-chin samples were conducted for organoleptic attributes such as; colour, aroma, taste, texture and general acceptability using twenty untrained panelists; students and staff of the Department of Food Science and Technology, Rivers State University of Science and Technology, Port Harcourt, Nigeria. The samples were served in a labelled white disposable plates and potable water was provided for mouth rinsing between the evaluations to avoid transfer of sensory attribute from one sample to the other. A 9-point hedonic scale as described by Iwe [21], where 9 denote extremely desirable and 1 denote extremely undesirable were used to score the Moringa enriched chin-chin.

2.6. Statistical Analysis

Analyses were done in triplicate and all data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS) version 20.0 software 2011. Duncan's New Multiple Range test was used to identify significant difference at 5% probability according to the method described by Wahua [22].

III. Results and Discussion

3.1. Proximate Composition of Dried Moringa Leaf Powder

The three drying methods significantly affected ($p<0.05$) the proximate composition of moisture, ash, protein and carbohydrate as shown in Table 2. Adeyemi et al., [17] equally reported significant effect in crude protein, ash, moisture and carbohydrate content of Moringa oleifera using different drying methods. Among the three drying techniques, sun and shade drying had no significant effect on fibre and fat content of the dried leaves. Oven dried sample had higher fibre and lower fat. The value for moisture content ranged from 1.65% to 5.89% and the highest value was observed in shade dried sample. The observed moisture values reported in this research fall within the range of 2.367 – 5.487% for dried Moringa leaf observed by Adeyemi et al., [17] using the same drying techniques as in this study. Low moisture content reported here is in agreement with Mbah et al., [11] and equally low compared to 10% recommended for dried vegetables [23]. Ash content ranged from 6.02% to 9.90% and the highest value was recorded on the shade dried sample. This is high compare to ash content of Moringa leaves from two areas in Eastern part of Nigeria reported by Mbah et al., [11]. This could be attributed to differences in location, variety, soil type and temperature at which the leaves were dried. Protein content ranged from 28.21% to 32.14% for oven and sun dried samples, respectively and shade dried sample had 26.57% protein content. Price [24] reported 100g fresh Moringa leaves with protein range of 5 – 7mg/100g and Mbah et al., [11] reported a range of 6.13 – 10.78mg/100g for fresh Moringa leaves. The protein value reported in this study for dried Moringa and fresh leaves reported by these researchers agreed with the phenomenon that loss in moisture value of dried leaves increased nutrient density. Dried Moringa leaf (DML) samples had fibre range of 5.02% to 6.13% for sun and oven dried samples, respectively while shade dried had 5.18%. This range agreed with the result of Subadra and Monica [25]; Adeyemi et al., [17]. Mensah et al., [26] reported much higher fibre content using shade drying method and this could be attributed to the location of the analysis. Fibre cleanses digestive tract by removing potential carcinogens from the body and preventing the absorption of excess cholesterol [27]. The dried leaves was observed to contain low fat with a range of 1.12 –

2.75% for oven and shade dried samples, respectively and sun dried sample had fat content of 2.51%. Mbah et al., [11] reported high fat content of fresh Moringa leaves and low in dried leaf samples. This indicates that drying was effective in reducing the fat content of Moringa leaves. Dried leaves with low fat content have an advantage of a long shelf life without the formation of rancidity (off-flavour) more than those with high fat value. The value for carbohydrate ranged from 19.07% to 29.32% for shade and oven dried Moringa leaf samples, respectively and 24.09% was recorded for sun dried sample. This is low compare to the range of 51.03 – 66.39% for carbohydrate content of dried Moringa leaves and high compare to fresh Moringa leaves with a range of 1.12 – 9.26% reported by Mbah et al., [11]. Adeyemi et al., [17] equally reported the range of 54.183 – 72.977% for the carbohydrate content of various dried Moringa leaf samples. The increase in carbohydrate value after drying could be due to utilization by microflora for the formation of carbon skeleton for synthesis of nutrients. Carbohydrates contribute to fat metabolism and spare proteins as energy source for human beings [13, 28]. The result of the proximate composition of dried Moringa leaves agreed with the statement that dried food materials are more nutrient dense.

Table 2: Proximate composition of dried Moringa leaf powder

Parameters (%)	Oven dried	Sun dried	Shade dried
Moisture	1.65 ± 0.05^{c}	4.25 ± 0.05^{b}	5.89 ± 0.05^{a}
Ash	6.02 ± 0.05^{c}	8.05 ± 0.05^{b}	9.90 ± 0.05^{a}
Protein	28.21 ± 0.05^{b}	32.14 ± 0.05^{a}	26.57 ± 0.05^{c}
Fibre	6.34 ± 0.05^{a}	5.02 ± 0.05^{b}	5.18 ± 0.05^{b}
Fat	9.12 ± 0.05^{b}	10.51 ± 0.05^{a}	10.75 ± 0.05^{a}
Carbohydrate	29.32 ± 0.05^{a}	24.09 ± 0.05^{b}	19.07 ± 0.05^{c}

Means with different superscripts in a row differs significantly at 5% level of probability ($p<0.05$)
± = Standard Deviation of Triplicate Determinations

3.2. Mineral Composition of Dried Moringa Leaf Powder

From the result, it was observed that drying techniques studied had no significant effect ($p<0.05$) on magnesium content of the (DML) powder samples as presented in Table 3. Oven and sun dried samples recorded the same values of 16.5mg/100g while shade dried had magnesium content of 16.7mg/100g. This suggested that none of the drying techniques had an advantage over the other in improving the magnesium value of the dried leaves. A range of 80 – 120mg/100g of magnesium and 350 – 550mg/100g of calcium of fresh Moringa oleifera leaves reported by Price [24] is an indication that these minerals were reduced by drying. Oven drying method effectively preserved the calcium value more than other samples up to 190.5mg/100g, followed by shade drying (189.4mg/100g) and lastly sun drying technique (165.5mg/100g) with significant difference ($p<0.05$) in all the samples. Iron had a range of 30.2 – 51.3mg/100g for oven and shade dried samples, respectively, 41.2mg/100g for sun dried leaves and showed significant difference in all the leaf samples. Sun dried sample had significantly higher zinc 7.1mg/100g, followed by shade dried with the value of 5.4mg/100g and lastly 4.2mg/100g for oven dried sample. This agreed with the report of Mbah et al., [11] who observed that sun drying method was found to be more effective in preserving the zinc value of Moringa leaf powder more than other methods studied. From the report of Price [24] for nutritional values of fresh Moringa oleifera leaves and the ones observed in this present research for (DML) powder, it can be said that drying techniques studied decreased magnesium and calcium values while an increase in iron and zinc were observed. Though, oven drying preserved more calcium, shade drying more iron and sun drying improved zinc content. It was equally observed that the mineral content of the dried leaves reported here were much high compare to those reported by Mbah et al., [11] using same drying methods. This could be associated with the environmental conditions such as humidity and temperature of the analytical environment.

Table 3: Mineral Content of Dried Moringa leaf powder (mg/100g)

Parameters	Oven dried	Sun dried	Shade dried
Magnesium	16.5 ± 0.05^{a}	16.5 ± 0.05^{a}	16.7 ± 0.05^{a}
Calcium	190.5 ± 0.05^{a}	165.5 ± 0.05^{c}	189.4 ± 0.05^{b}
Iron	30.2 ± 0.05^{c}	41.2 ± 0.05^{b}	51.3 ± 0.05^{a}
Zinc	4.2 ± 0.05^{c}	7.1 ± 0.05^{a}	5.4 ± 0.05^{b}

Means with different superscripts in a row differs significantly at 5% level of probability ($p<0.05$)
± = Standard Deviation of Triplicate Determinations

3.3. Proximate Composition of Chin-Chin Enriched with Dried Moringa Leaf Powder

Moisture content of chin-chin enriched with dried Moringa leaf (DML) powder from various drying techniques ranged from 2.56% to 5.93% for samples D and C, respectively as shown in Table 4. Samples B and C had significantly higher moisture compare to sample A (4.88%) and D had significantly lower moisture content as shown in Table 4. This is in agreement with the range of 3.98 – 5.04% for moisture content of chin-chin produced from composite flour of wheat/millet reported by Adegunwa et al., [29]. Sanni et al., [30] stated

that the lower the moisture contents of a product, the better the shelf stability of such products. Hence, low moisture ensures higher shelf stability of dried products. A range of 1.50 – 1.73% (samples D and A, respectively) was observed for ash value of the produced chin-chin. Various drying techniques studied showed no significant effect ($p<0.05$) on the product when compared to the control sample in regards of the ash content. Ash values reported here are low compared to 4.94 – 6.10% for wheat/millet chin-chin reported by Adegunwa et al., [29]. The difference in these reports could be associated with the use of different food materials such as grains and vegetables. Fasasi [31] reported that low fat content on dried sample helps to increase the shelf life of the product by decreasing the chances of rancidity and also contribute to low energy value of the food product while high fat in a product will increase high energy value and promotes lipid oxidation. Fat value in this study ranged from 2.03% to 24.79% with the control sample (A) having the lowest fat content and D with the highest value. A significant difference was observed in all the samples. The product might have absorb more fat during processing which led to its high fat value as the range of 1.12 – 2.75% was observed in the (DML) samples. The produced chin-chin can serve as high energy food to children who require enough energy to support their growth. Enrichment of chin-chin with (DML) powder significantly increased the protein content of the product compared to the control (sample A). The highest increment was observed in sample D (shade dried) with the value of 11.21%, followed by sample C (8.97%), sample B (8.05%) and lastly the control (sample A) with protein value of 6.99%. This agreed with literature stated by Rajangam et al., [9] that Moringa leaves may be regarded as a protein and calcium supplement and calcium of the (DML) samples reported in this research were equally high. The protein quality of shade dried Moringa leaf chin-chin (sample D) is high compare to 10.7% for cookies enriched with 10% Bambara groundnut protein concentrate produced from plantain flour reported by Kiin-Kabari and Giami [32]. Enrichment of (DML) powder was found to improve the fibre content of the product when compared to the control sample. Fibre content of sample D (2.56%) was significantly higher ($p<0.05$) compare to other samples. There was no significant difference between samples A, B and C with fibre values of 1.29, 1.37 and 1.26%, respectively. Carbohydrate content was observed to range between 57.41 – 66.35% for sample D and C (lowest and highest), respectively. This is within the range of 57.41 – 63.35% for composite flour of chin-chin reported by Adegunwa et al., [29] and equally observed no significant difference in all the samples. Generally, lowest moisture, ash and carbohydrate was observed in chin-chin produced with shade drying method as well as highest fat, protein and fibre contents of the product.

Table 4: Proximate Composition of Chin-chin Enriched with dried Moringa leaf powder

Parameters (%)	Control (A)	Oven dried (B)	Sun dried (C)	Shade dried (D)
Moisture	4.88 ± 0.03^{b}	5.87 ± 0.06^{a}	5.93 ± 0.12^{a}	2.56 ± 0.05^{c}
Ash	1.73 ± 0.05^{a}	1.50 ± 0.05^{a}	1.70 ± 0.05^{a}	1.54 ± 0.05^{a}
Protein	6.99 ± 0.05^{d}	8.05 ± 0.05^{c}	8.97 ± 0.05^{b}	11.21 ± 0.05^{a}
Fibre	1.29 ± 0.05^{b}	1.37 ± 0.06^{b}	1.26 ± 0.12^{b}	2.56 ± 0.05^{a}
Fat	2.03 ± 0.05^{d}	15.79 ± 0.05^{c}	18.61 ± 0.05^{b}	24.76 ± 0.06^{a}
Carbohydrate	64.08 ± 0.05^{c}	64.56 ± 0.05^{b}	66.35 ± 0.05^{a}	57.41 ± 0.05^{d}

Means with different superscripts in a row differs significantly at 5% level of probability ($p<0.05$)
± = Standard Deviation of Triplicate Determinations

3.4. Sensory Properties of Chin-Chin Enriched with Moringa Leaf Powder

The result of the sensory evaluation showed that there was no significant difference ($p<0.05$) in all the sensory attributes of colour, aroma, taste, texture and general acceptability of chin-chin produced from various (DML) powder as presented in Table 5. Control chin-chin sample was preferred in all the organoleptic characteristics studied compared to other samples enriched with (DML) powder. Adegunwa et al., [29] also reported more preference in sensory attributes of chin-chin produced with 100% wheat flour compared to those from composite flour of wheat/millet. This is equally similar with the observation of Emelike et al., [8] of a more likeness of cookies produced with 100% wheat flour compared to cookies fortified with 5% dried Moringa leaf powder. For the general acceptability of dried Moringa enriched chin-chin in this research to range between 7.1 – 7.2 on a 9 point hedonic scale is an indication that they were equally accepted by the panelists. Awareness on the numerous health benefits of Moringa needs to be created to increase panelists' acceptability of food products enriched or substituted with Moringa oleifera leaves.

Table 5: Sensory Properties of Chin-Chin Enriched with Dried Moringa leaf Samples

Sample	Colour	Aroma	Taste	Texture	General acceptability
Control (A)	8.2^{a}	7.9^{a}	7.8^{a}	7.8^{a}	7.9^{a}
Oven dried (B)	6.8^{b}	6.8^{b}	7.1^{b}	7.1^{b}	7.2^{b}
Sun dried (C)	6.5^{b}	6.9^{b}	6.9^{b}	7.2^{b}	7.1^{b}
Shade dried (D)	6.9^{b}	6.3^{b}	7.1^{b}	6.9^{b}	7.1^{b}
LSD	0.8	0.7	0.7	0.6	0.7

Means with different superscripts in a row differs significantly at 5% level of probability ($p<0.05$)
± = Standard Deviation of Triplicate Determinations

IV. Conclusion

Among the three drying techniques studied, oven drying was effective in decreasing the moisture and fat as well as increasing the fibre and carbohydrate values of the dried Moringa leaf (DML) powder. Highest protein value of 32.14% was observed on the sun dried leaf sample. Apart from magnesium, significant difference ($p<0.05$) was observed in the mineral contents studied. Highest calcium was observed in the oven dried sample, iron in the shade dried and zinc in the sun (DML) powder. Enrichment of 1% shade (DML) powder in chin-chin was found to increase the protein, fibre and fat content of the product and lowest moisture and carbohydrate values compare to other samples. The sensory evaluation of the chin-chin samples showed that the control sample was preferred more than samples with Moringa leaf enrichment. But for the fact that the general acceptability of chin-chin samples enriched with (DML) powder scored 7.1 and above on a 9 point hedonic scale showed that these products were also accepted by the panelists. A significant effect was not recorded in the sensory attributes of all the (DML) powder enriched chin-chin.

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