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Effect of Drying Methods on the Physico-Chemical and Sensory Properties of Cookies Fortified with *Moringa* (*Moringaolelfera*) Leaves

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ABSTRACT----*The study was undertaken to determine the effect of drying methods on the physicochemical and sensory properties of wheat flour cookies produced with Moringa powder fortification. Cookies were produced with Moringa leaf powder derived from various drying methods (shade drying, sun drying and oven drying) and fresh leaves prior to milling and used in the formulations. The physical properties, proximate compositions and sensory attributes of the cookies were analysed. The results showed significant differences in weight of all the cookie samples from various drying methods while there was no significant difference in the fresh leaves and control cookie samples. Oven dried sample was the least in height (0.67), higher in diameter (3.80) and spread ratio (5.79) compared to other drying methods studied. All Moringa supplemented cookies had significantly lower (P<0.05) ash and fat contents than the control sample with ash and fat content of (2.06mg/100g and 20.32mg/100g), respectively. There was no significant difference between the protein content of the control cookie samples and cookies prepared from various drying methods studied. All the Moringa fortified cookies had significantly (p>0.05) higher fibre compared to the control sample. Sensory scores showed highest acceptability with the control sample (8.30) but there was no significant difference between the general acceptability of shade and sun dried samples (6.95 and 6.70), respectively. The findings suggest preliminary prospects for the development of Moringa fortified cookies for potential nutritional health benefits.*

Keywords---- Drying methods, Physicochemical, Sensory properties, Fortified cookies, *Moringa* leaves.

1. INTRODUCTION

The consumption of cereal foods such as biscuits/cookies and bread has become very popular in Nigeria; especially among school children. Most of these foods are however poor sources of protein that is often of poor nutritional quality [1, 2]. Thus, the production and utilization of fortified processed foods is therefore one potential way of providing adequate nutritional needs. Although, the actual processing of food may add to its cost, the use of cheap, yet nutrient rich raw materials could make them economically viable nutritional sources [3]. Incorporating *Moringa* in baked foods may be exploited as a means of boosting nutrition in Africa and Asia where malnutrition is prevalent [4].

Malnutrition is the insufficient or imbalanced consumption of nutrients [5]. A number of different nutritional disorders may arise, depending on which nutrients are under or over abundant in the diet [3]. The World Health Organisation cited malnutrition as the gravest single threat to the world's public health [5].

Fortification of cereal-based foods with other protein sources such as oil seeds and legumes has received considerable attention to fight malnutrition [6]. This is because these protein sources are high in lysine, an essential limiting amino acid in most cereal [7]. A salient source for incorporation however, should be vegetables such as *Moringa* leaves with high nutritive value as well as functional benefits.

The study carried out by Johnson [8], observed that the leaf, seed and fruits of *Moringaoleifera* are naturally rich sources of vitamins and minerals. In an analysis of 100 grams of the edible portion of fresh *Moringaoleifera* leaves parts have shown to contain much of the following water soluble vitamins; 2.6mg of vitamin B1 (thiamine), 20.5mg of vitamin B2 (riboflavin), 8.2mg of vitamin B3 (nicotinic acid) and 220mg of vitamin C. In addition, this same portion of edible product contains the following fat-soluble vitamins: 16.3mg of vitamin A, 113mg of vitamin E (alpha-tocopherol acetate) as much as 423mg of the lipotropic element, chorine, 19.2 grams of fibre and several key minerals: 2003mg of calcium,

368mg of magnesium 204mg phosphorus, 1324mg of potassium, 3.1mg of copper, 28.2mg of Iron and 870mg of selenium [8].

In addition to these vitamins and minerals, one of the most significant benefits of *Moringaoleifera* is the ability of this plant to provide as much as 27.1 grams of protein (nearly one-third of the edible portion); containing all of the essential amino acids. These leaves could be a great boom to people who do not get protein from animal source such as milk and egg. It also contains arginine and histidine, the two amino acids especially important for infants [9].

The protein quality of *Moringa* leaves compares very well with that of milk and eggs [10].*Moringa* is the sole genus of the flowering plant *Moringaceas* with thirteen species out of which are; *Moringaoleifera, Moringastenopetala, Moringa peregrine and Moringa doughardii. Moringa* leaves contain seven times the vitamin C of oranges, four times the vitamin A of carrots, four times the calcium of milk, three times the potassium of bananas and two times the protein in yoghurt [9].

A large number of reports on the nutritional quality of *Moringa* now exist in both the scientific and the popular literature. *Moringa* plant is an exceptionally nutritious tree with a variety of potential uses [11]. The leaves can be consumed either in raw, cooked or dried over a screen for several days and ground into a fine powder that can be added to almost any food as a nutrient supplement [12], such as pap, cereals and drinks to improve their nutritive value [10].

Drying and packaging is usually employed to preserve the leaves and fruits for later use and to increase its shelf life. The dried *Moringa* like most vegetables that are perishable are normal phenomenon in open markets found in most West African countries where they are sold [13]. Scientists have used dried and packaged materials for the extraction of biological active compounds and to preserve its vitamins.Effect of drying techniques on the proximate and other nutrient composition on *moringa* leaves have been studied by Mbah *et al.*, [14]. Adeyemi*et al.*, [15] carried out a research on the influence of drying methods on the proximate and phytochemical composition of *Moringa* leaves. Emelike& Ebere [16] reported the effect of packaging materials, storage conditions on the vitamin C and pH value of cashew apple juice.This is important since during drying, membranes of plant organelles containing different secondary compounds are destroyed, making extraction more efficient [17] while packaging is also an important aspect in food processing industry as it serves the function of containing the food, protecting against chemicals, physical damage and providing information on product features, nutritional status and ingredient [18].Plant leaves can be dried in a number of ways: in the open air (shaded from direct sunlight); placed in thin layers of drying frames, wire-screened or in buildings, by direct sunlight, if appropriate; in drying ovens/rooms and solar dryers; by indirect fire; baking; lyophilisation; microwave or infrared devise.

These attributes of *Moringa* reported above stimulated undertaking the current study. The main objective of this research is to evaluate the effects of drying methods on the physical, chemical and sensory properties of cookies fortified with *Moringa* leaves powder; thereby replacing the use of milk and egg in the formulation for the production of cookies.

2. MATERIALS AND METHODS

2.1. Collection of Materials

Moringa (*Moringaoleifera*) leaves were harvested from the Diplomat Farms and Services Limited (*Moringa* and Mushroom farm) a research centre in the Rivers State University of Science and Technology, Port Harcourt,Rivers State, Nigeria. Baking itemssuch as flour (Dangote), margarine (Simas), sugar (Double crown), baking powder (Double crown), vanilla essence (Foster Clark's), salt (Anapuna) and nutmeg (Goodluck Super Quality) were all purchased from a bakery shop in Mile 3 Market, Port Harcourt,Rivers State, Nigeria.

2.2. Preparation of Samples

Moringaoleifera leaves were harvested from stem by hand, sorted and weighed with total weight of 1.3kg. This was further divided into three parts of 400g each for the three methods of drying (shade drying, sun drying and oven drying). Each part was passed under a running tap and damped with a clean cloth to remove excess water. The sample for shade drying were spread in two trays and placed on a high plane in the shade while the sample for sun drying were also spread in two trays on a table under the sun. The last part was spread in two foiled trays in an oven at 50^{o}C overnight to achieve the oven dried sample. Fresh *Moringa* leaves were harvested on the day of incorporation, sorted, weighed, washed and milled. All samples (fresh and dried) were milled with Philips Spice grinder, (model HR 1701/BC, U.K).Flow chart for the preparation of samples is presented in Figure 1.

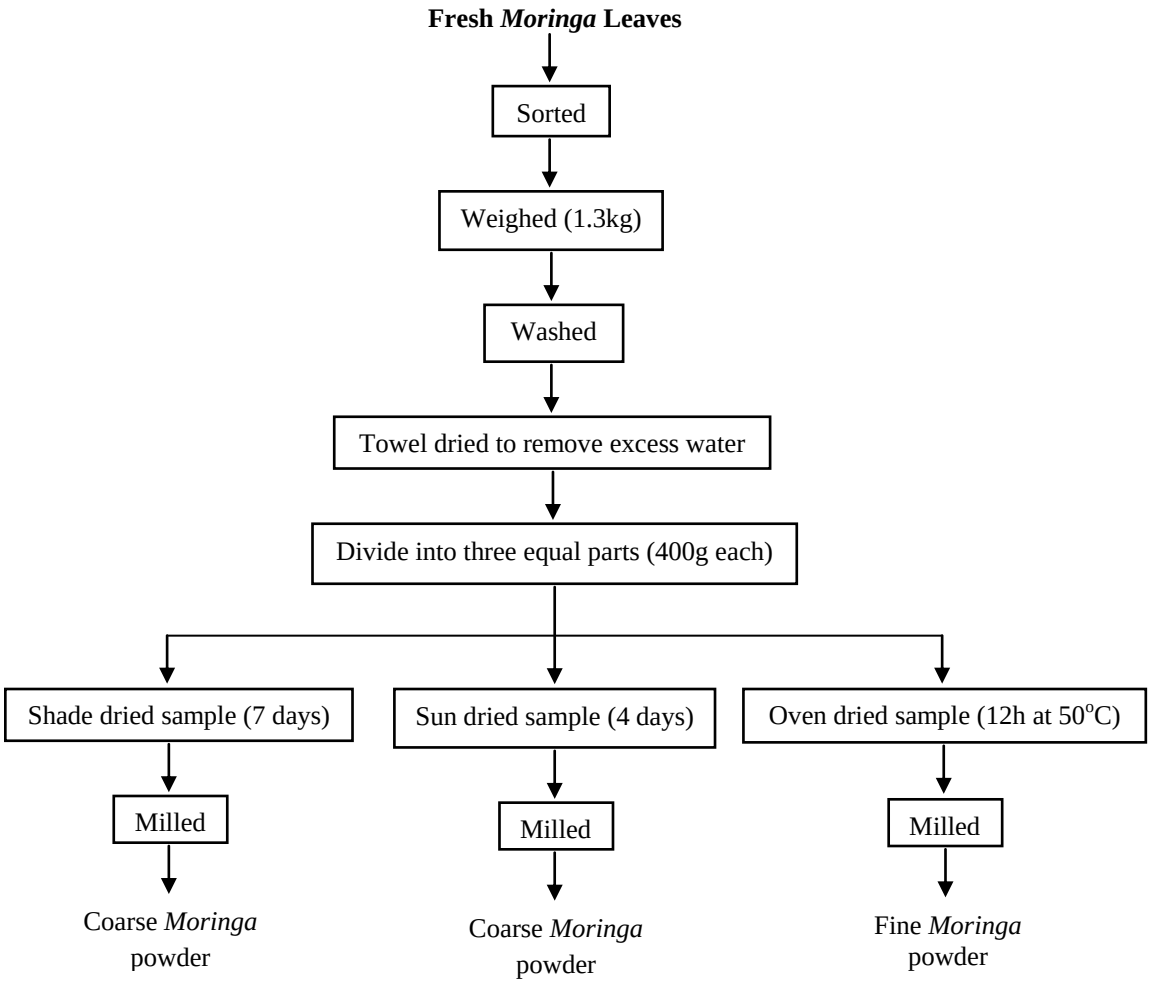

Figure 1: Flow chart for the preparation of *Moringa* powder and paste.

Source: Author's Computation.

2.3. Preparation of Cookies

Wheat flour was sieved using 250 micron particle size sieve and set aside in a bowl. This was then mixed with other ingredients (baking powder, salt, sugar, nutmeg and *Moringa* powder) to ensure uniform incorporation. Margarine was rubbed in until a texture in a form of bread crumbs was formed. Water, flavourand vanilla essence was added to produce dough that was then rolled out in a clean flour-dusted surface and cut into small circular sizes of about 3cm in diameter and 0.5 cm in height. An average of 65 cookies were cut from each sample and lined in a greased baking pan and baked at 170°C in the oven (Omega Dako, Model-Ms 209) for 18 min. The cookies were allowed to cool on a rack and then used for analyses.

Table 1: Formulation of *Moringa* cookie recipe

Samples	Flour (g)	Margarine (g)	Sugar (g)	Baking Powder(g)	Salt (g)	Vanilla Essence(mg)	Nutmeg (g)	Water (ml)	*Moringa* (g)	Milk (g)	Egg
WF	200	100	60	5	2.5	5	2.5	50	0	5	1
FL	200	100	60	5	2.5	5	2.5	50	5	0	0
SHD	200	100	60	5	2.5	5	2.5	50	5	0	0
SD	200	100	60	5	2.5	5	2.5	50	5	0	0
OD	200	100	60	5	2.5	5	2.5	50	5	0	0

Key: Wheat flour (WF), fresh *Moringa* leaves (FL), Shade dried M*oringa* leaves (SHD), Sun dried *Moringa* leaves (SD), Oven dried *Moringa* leaves (OD).

2.4. Physical Characteristics of Cookies

The cookie weight, diameter, height and spread ratio were measured using five randomly selected cookies from each sample as described by Oyewole*et al*., [19]. Cookies' weight was taken by scaling five cookies from each sample and the average noted. The diameter (D) was measured by taking two measurements from one cookie in 90^{o} rotations. A total of five cookies were measured from each sample and the average noted. The height (thickness) of cookies was measured by taking three measurements from one cookie and total height of the five cookies takenand the meanwas noted.

2.5. Chemical Analysis of Cookies

Standard assay method [20] was used to determine the proximate composition of the cookies for moisture, crude protein, fat, crude fibre and ash.Total and available carbohydrate was determined using the anthrone reagent method as described by Osborne &Voogt [21].

2.6. Sensory Evaluation

Sensory evaluation of the samples were conducted using twenty (20) untrained panellists; students and staff of the Department of Food Science and Technology, Rivers State University of Science and Technology, Port Harcourt,Rivers State, Nigeria.Nine coded cookie samples were presented to each panellist for each session. They assessed the cookies for colour, texture, crispness, taste, aroma and general acceptability using 9-point hedonic scale as described by Iwe [22], with 1 and 9 representing the least score (dislike extremely) and the highest score (like extremely), respectively.

2.7. Statistical Analysis

Complete randomized design was used in assigning samples to groups. Data obtained for all determinations were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0 software 2011. Duncan's New Multiple Range test was used to identify significant difference among treatment means at $p \leq 0.05$.

3. RESULT AND DISCUSSION

Physical properties of the cookies' weight, height, diameter and spread ratio is presented in Table 2. From the result,the control sample had significantly higher ($P<0.05$) weight than cookies from sun andovendried leavessamples while fresh leaves comparedwith the control.The diameter and spread ratio of cookies prepared from oven dried leaves were significantly higher compared to cookies from other drying methods. This is in agreement with Oluwamukomi*et al*.,[23]; who stipulated that enrichment of biscuit with soy flour at substitution level above 40% resulted in increase in the diameter and the spread ratio but with an initial decrease in weight. In terms of height, cookies from fresh leaves compared favourably with the control. However, there was no significantdifference ($p>0.05$) between the oven dried and sun dried samples. This observation was similar with the report of Ebere *et al*.,[24], who observed no significant difference in height between the sun dried and oven dried samples of cookies prepared from wheat flour and cashew-apple residue. The spread ratio of the control sample was significantly lower compared to cookies from all the drying methods employed. This could be as a result ofthe salient source of fibre in *Moringa* leaves which is devoid in the control sample. Oyewole*et al*.,[19]; Ogunjobi&Ogunwolu[25], reported that fibre has the ability to absorb water up to 15 times and swelling up in size.

Table 2: Physical properties of cookies

Sample	Weight(g)	Height (cm)	Diameter (cm)	Spread ratio
WF	6.74^{a}	0.96^{d}	3.47^{c}	3.71^{c}
FL	6.62^{a}	1.00^{a}	3.78^{a}	3.93^{c}
SHD	6.35^{ab}	0.82^{b}	3.66^{b}	4.61^{b}
SD	5.45^{c}	0.75^{c}	3.58^{b}	4.80^{b}
OD	5.75^{bc}	0.67^{d}	3.80^{a}	5.79^{a}

Mean with similar superscripts in the same column are not significantly different ($P > 0.05$).

Key: Wheat flour (WF), fresh *Moringa* leaves (FL), Shade dried M*oringa* leaves (SHD), Sun dried *Moringa* leaves (SD), Oven dried *Moringa* leaves (OD).

The proximate composition of the cookie samples are shown in Table 3. The moisture content ranged from 4.19% to 5.88%. The moisture content was observed to be significantly higher in sun dried, shade dried and fresh leaves. It is only the cookies prepared from oven dried method that compared favourably with the controlsample(4.19% and 4.22%),respectively.However, the moisture content of the cookies was lower compared to the 10% recommended by FAO [26] for dried vegetables. Fat and ash content of the control sample(2.06g/100g and 20.32g/100g),respectivelywere significantly higher than other samples. This does not agree with the findings of Aluko*et al*.,[27] who observed an

increase in fat and ash content with incorporation of *Moringa* seed flour. This variation may be due to high oil content in *Moringa* seeds that is devoid in *Moringa* leaves.

There was no significant ($p>0.05$) difference in protein content ofcookies from all the processing methodsstudied compared tocookies producedfrom whole wheat flour (10.03%).This agrees with the statement of Gardener & Ellen [10] who report that the protein quality of *Moringa* leaves compares very well with that of milk and egg.A finer particle size (powder) was produced fromsun dried sampleanda more uniform incorporation was achieved. Other drying methods produced patches of green on cookies indicating that the incorporation was not homogenous. A salient finding however, is the increase in fibre content of all the *Moringa* cookie samples as against the control devoid of *Moringa* inclusion with the highest fibre content found in the sun dried samples (2.33%) and lowest in the control sample (WF at 1.05%). This is in agreement with Jadhas *et al.*,[28] who stipulated that *Moringa* leaves are high in fibre and increase in fibre content aids digestion.

Table 3: Proximate composition of cookies (%).

Sample	Moisture	Ash	Fat	Protein	Fibre	Total Carbohydrate
WF	4.22^{c}	2.06^{a}	20.32^{a}	10.03^{a}	1.05^{c}	62.32^{b}
FL	4.86^{b}	1.87^{b}	18.67^{b}	9.60^{a}	1.93^{b}	63.07^{a}
SHD	5.00^{b}	1.83^{b}	18.96^{b}	9.73^{a}	1.45^{d}	63.03^{a}
SD	5.88^{a}	1.90^{a}	18.15^{bc}	9.99^{a}	2.33^{a}	62.75^{a}
OD	4.19^{c}	1.78^{c}	17.49^{c}	9.94^{a}	1.78^{c}	61.91^{b}

Means with similar superscripts in the same column are not significantly different ($P > 0.05$).

Key: Wheat flour (WF), fresh *Moringa* leaves (FL), Shade dried M*oringa* leaves (SHD), Sun dried *Moringa* leaves (SD), Oven dried *Moringa* leaves (OD).

Scores from the sensory evaluation showed that the control sample was highest in general acceptability (8.30) but sample from the lesser weight of the fresh leaves (7.38), were found to be similar ($P>0.05$) with those from the control as presented in Table 4. This is in agreement with the value obtained by Aluko*et al.*,[27], where the lesser percentage of the mix (7.5%) was preferred (2.93 using a 5 point hedonic scale) by the panellists as the structure of the cookies was slightly distorted.

Cookies made from the powder of oven dried *Moringa* leaves with smaller particle size, were completely green in colour and showed less preference in colour characteristics assessed. This is in agreement with Van *et al.*, [29]; Bell & Weaver, [30]; Teye *et al.* [31]. Teye *et al*., [31] observed that when the colour of a new product differs from the standard products, consumers may see it as a sign of spoilage and consequently reject them. It is also in agreement with the result of Ogunsina&Radhac,[4] who in their study of replacing 30% debittered *Moringa* seed grits with the flour affected the cookies characteristics.

Table 4: Sensory evaluation of cookies

Samples	Colour	Texture	Crispness	Taste	Aroma	General Acceptability
WF	8.30^{a}	7.65^{a}	7.50^{a}	7.90^{a}	7.55^{a}	8.30^{a}
FL	7.40^{b}	7.00^{b}	6.75^{b}	6.80^{b}	7.00^{ab}	7.38^{b}
SHD	6.95^{c}	6.70^{b}	5.95^{c}	7.00^{ab}	6.55^{b}	6.95^{bcd}
SD	7.05^{c}	6.10^{c}	5.10^{d}	6.55^{d}	6.85^{b}	6.70^{bcd}
OD	6.00^{d}	6.75^{b}	6.80^{b}	7.05^{b}	7.00^{ab}	7.10^{bc}

Means with similar superscripts in the same column are not significantly different ($P > 0.05$).

Key: Wheat flour (WF), fresh *Moringa* leaves (FL), Shade dried M*oringa* leaves (SHD), Sun dried *Moringa* leaves (SD), Oven dried *Moringa* leaves (OD).

4. CONCLUSION

Cookies were successfully produced from wheat flour incorporated with *Moringa* leaves flour. This was a means of providing an alternative to milk and egg for vegetarians. From the result, there was no significant difference between the protein content of cookies produced without egg and milk but with *Moringa* leaves inclusion and those produced with egg and milk without *Moringa* leaves inclusion. This is an evident that *Moringa* leaves powder can actually be used in the production of cookies to replace egg and milk to enable vegetarians to benefit from cookies in the open market.

Another good finding was an increase in fibre content of cookies enriched with 5% *Moringa* leave flour. This showed that *Moringa* leaf possessed the characteristics of a functional ingredient.Generally, any of the drying methods can be used to process *Moringa* leaves into flour for use as food supplement.

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