Short Research Article

Drying Effect of Energy Storage Enhanced Multilayer Solar Dryer (ESEMSD) Parameters on the Physicochemical Properties of Dried *OGI*

Abstract

This study evaluated the effect of Enhanced Multilayer Solar Dryer on some physical properties of *ogi* powder; the *ogi* was subjected to different variations inside the Enhanced Multilayer Solar Dryer; Fan application/no fan application, placement of tray (Topmost tray and middle tray) and the kind of storage (thermal storage and no thermal storage). At all placement levels inside the dryer, the moisture content and drying rate decreased significantly with an increase in drying time and temperature. The Bulk density follows a similar trend at all levels of variations in the dryers, ranging from 0.64 to 0.74 g/cm^3. The result shows that sedimentation volumes were not influenced by variations in the solar dryer, and the values vary from 15 to 45 cm^3. The titratable acidity ranges from 0.79 to 1.07 g/L. It was observed in this research that the Enhanced Multilayer Solar Dryer had less or no impact on the Physicochemical Properties of dried *ogi and can* be an alternative use, especially in locations with limited access to electricity.

Keywords: Ogi, pH, solar dryer, temperature, total titratable acidity

1. Introduction

Ogi is a fermented starchy paste traditionally obtained by submerged fermentation of some cereals (Adegunwa *et al.*, 2011). It is made from several cereal-based feedstocks such as maize (*Zea mays*), millet (*Pennisetum typhoides*), Sorghum (*Sorghum bicolor*), or Guinea corn (*Sorghum spacers*) as reported by (Ohenhen and Ikenemoh 2007). It is a popular cereal food in West Africa, especially in the Southern part of Nigeria, where it serves as a staple food for many and is commonly used as the first native food given to babies at weaning, breakfast meal for adults, and food of choice for the sick and the elderly ones. It also has its application in traditional medicine (Ojokoh, 2009). *Ogi* is very critical to the diet of rural communities in Southern Nigeria and *garri* were the most frequently consumed fermented foods in that area (Aderiye and Laleye, 2003). In Oyo state, Nigeria, for instance, out of the total food processing industries in the state, cereal grain processing industries using maize as their raw material to produce *Ogi* constitutes about 11.9% (Ajayi, 2004). In Nigeria, *Ogi* is prepared and consumed as *Akamu, Akassan* or *Koko* among the Yorubas, Ibos and Hausas, respectively (Egwim *et al.*, 2013). However, it is called *Akosa*in Ghana (Adegbehingbe, 2013). In ancient times *Ogi* was designed specifically to suit young children during feeding. But later, it is consumed by all groups of people (Wasiu *et al.*, 2016).

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Recently, there has been increasing in the industrial production of this food in powdery form. *Ogi* powder is often packaged in sachets and sold for consumption. Dried *Ogi* are expected to have a stable shelf life compared to wet *Ogi* (Bolaji and Oyewo, 2017). Still, little has been done on the associated bio-deterioration fungi, which are majorly responsible for the spoilage of this product, and control measures for its possible aflatoxin contamination.

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Ogi is an important food for many people in various parts of Nigeria and in some other West African countries. However, some of the challenges facing the production of *Ogi* are nutrient losses which occur at different stages of its production (Awoyale *et al.*, 2016), and its contamination by fungi. It was observed by Jonathan (2017) that the storage time significantly reduced the nutrient content of the *Ogi* samples between week 0 and week 8; this could be a result of the deteriorating activities of the associated fungi in the *Ogi* powder. Fungi, as saprophytic organisms, usually act on food as substrate and deteriorate them in other to absorb nutrients from them. Fungal occurrences in dry store foods may be due to their capacity to adapt and survive in dry conditions. (Amusa *et al.*, 2005).

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It is estimated that 20% of the world's grain production is lost after harvest because of inefficient handling and poor implementation of post-harvest technology. Grains and seeds are normally harvested at a moisture level between 18% and 40%, depending on the nature of the crop. These must be dried to a level of 7% to 11% depending on application and market need. The length of time a cereal can be safely stored will depend on the condition it was harvested, and the storage facility being utilized. Grains stored at low temperatures and moisture contents can be kept in storage for longer periods before their quality deteriorates.

Energy requirements (sun and wind) are readily available in the ambient environment, and little capital is required. This type of drying is frequently the only commercially used and viable method in which to dry agricultural products in developing countries. The safer alternative to open sun drying is a solar dryer. This is a more efficient method of drying that produces better quality products but also requires initial investments. If drying conditions such as weather and food supply are good, natural circulation solar energy and solar dryers appear to be increasingly attractive as a commercial proposition.

According to (Madhlopa et al., 2002); Traditional drying, which is frequently done on the ground in the open air, is the most widespread method used in developing countries because it is the simplest and cheapest method of conserving foodstuffs but possesses more disadvantages like the exposure of the foodstuff to rain and dust, uncontrolled drying; exposure to direct sunlight which is undesirable for some foodstuffs, infestation by insects, and attack by animals.(Mujumdar *et al.*, 2000) pointed out that numerous new or improved drying technologies are currently at various stages of development, and over 400 dryer types have been cited in technical literature. However, only about 50 types are commonly found in practice. The solar dryer is suitable for food drying and

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evaporation processing operations for food products as it will help prevent products been dried from contaminations and promote uniform and more rapid drying. To make *Ogi* available all year round, there is a need to remove its moisture content to a safe level to maintain its quality and shelf life for better consumption without restrictions on the energy needed for the drying process, thereby encouraging the involvement of the rural communities in the production of Agricultural products.

Despite the ready availability of solar energy, its continuous usage has not been fully explored yet owing to the unpredictable nature of solar energies, resulting in varying thermal insolation at different times of the day (Olamide Durodola, 2022). Studies on the solar intensity of different places on a typical day, as reported by different researchers, show that the day usually starts with low solar insolation (6 am– 9 am), followed by high insolation (12noon –3 pm) and then by moderate insolation (4 pm -6 pm). Thus, attaining high temperatures, particularly during periods of low insolation, may be difficult. If continuous drying requires to be achieved, the solar dryer may be practically inefficient at night when there is no solar insolation. To effectively use solar dryers during this period, suitable means of thermal energy storage should be incorporated into the design of a solar dryer (Fagunwa et al., 2019).

It is with this working principle of a solar dryer, as shown in figure 1, which the investigation into the performance evaluation on the physical properties of *ogi* when subjected to different conditions in the dryer was conducted. This study was undertaken to know the unique characteristics of *Ogi* Powder when subjected to different conditions inside the solar dryer. This has the potential to determine the possible application of end-product suitability in *Ogi* powder processing.

Figure 1. The solar dryer. *A – Flat Plate Solar Collector B – Parabolic Solar Collector (Heat Storage Chamber) C – Drying Chamber D – Air duct Unit* (Fagunwa et al., 2019).

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2. Materials and Method

The dried yellow maize (*Zea mays*) used in this study was obtained from the local market in Ibadan, Oyo state, Nigeria (Figure 2). The maize grains were gently cleaned, and foreign materials were patiently removed, as shown in figure 3. The sample was soaked for 78 hours at room temperature (28 ± 2^{o}C). The soaked maize was decanted, wetly milled, and wet sieved with a muslin cloth of about 300 µm pore size, and the filtrate was allowed to sediment and ferment for 24 hrs to yield a wet cake known as "*Ogi*". The wet cake was introduced to a screw press to drain the moisture level to the minimum level and dried using Energy Storage Enhanced Multilayer Solar Dryer. The wet cake was subjected to different variations at different tray levels in the Energy Storage Enhanced Multilayer Solar drier, as shown in Table 1. The dried samples were pulverized using a locally made laboratory mill. The samples were packaged in a polyethylene bag and stored at ambient temperature for further analysis. All the analysis was replicated, and the data obtained were subjected to statistical analysis.

(a) (b)

Figure 2. (a) shows the wet *Ogi* powder before drying and (b) shows the dried *Ogi* powder using the ESEMSD.

Determination of Moisture content

Twenty grams (20g) of dried *Ogi* was weighed using a digital weighing balance (model no: JA10002 and accuracy of 0.01 g) into a previously weigh crucible and transferred into the oven set at 105°C to dry overnight. The crucible plus sample was removed from the oven and transferred into desiccators, cooled for 60 minutes, and weighed (Oginni, 2014). The moisture content of the samples used was determined and computed using the relations (equation 1) used by Kiin-Kabari *et al., 2018:*

Moisture content (MC) = $\left\{\frac{m_2 - m_3}{m_2 - m_1}\right\} x\ 100$ 1

Where M_1 is the mass of the container, M_2 is the mass of the container with the sample before drying, and M_3 is the mass of the container with the sample after drying.

Bulk density

The bulk density of the dried *Ogi* was also determined using the procedure of Petingco *et al.,* (2020) was used with slight modification. A specified amount of the powdered Ogi was put into an already weighed (W) 25ml measuring cylinder, it was gently tapped, and the volume was noted. The new sample level on the measuring cylinder was recorded in ml as (M). The bulk density was computed as shown in equation 2.

BULK DENSITY = $\frac{W}{M}$ 2

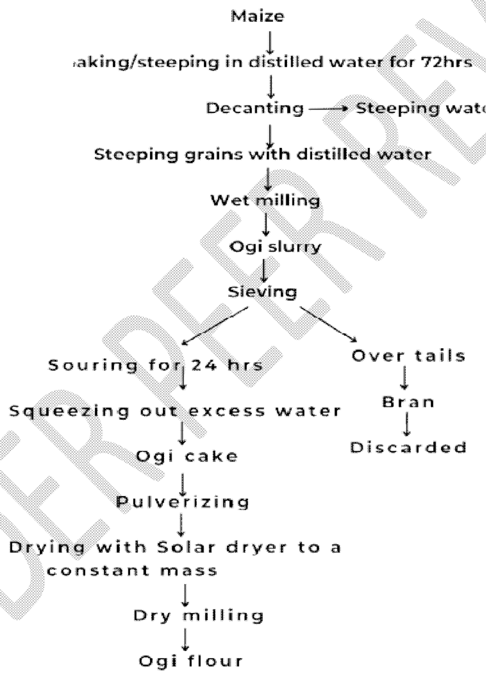

Figure 3. Flowchart used to produce *Ogi* powder.

pH determination

The dried *Ogi* was assessed chemically by determining the pH of the dried *Ogi* according to the method of Olaosebikan *et al.,* (2016). 10 g of the sample was added to 50 ml of distilled water and stirred for 10 min. The pH of the sample was determined by dipping the electrode of the Kent pH meter in the mixture. Duplicate determinations were made for all variations. The pH meter was calibrated using pH 4.0 and 9.0 buffers.

Table 1. Variations of placement in the Energy Storage Enhanced Multilayer Solar drier

S/N	Fan application	Tray placement	Storage
1	Fan applied	Topmost tray	Thermal storage
2	Fan applied	Bottom tray	Thermal storage
3	Fan applied	Topmost tray	No thermal storage
4	Fan applied	Bottom tray	No thermal storage
5	No fan applied	Topmost tray	Thermal storage
6	No fan applied	Bottom tray	Thermal storage
7	No fan applied	Topmost tray	No thermal storage
8	No fan applied	Bottom tray	No thermal storage

Titratable acidity

The titratable acidity (lactic acid-base) was determined by titrating 0.1M NaOH against 20 mL prepared from 8 g of the dried *Ogi* diluted with 80 mL of distilled water (Tyl & Sadler, 2017).

Sedimentation volume

The sedimentation volume was determined according to the procedure used by Deshmukh *et al.,* (2013). A 10g dry basis of Ogi powdered was weighed into a graduated 100 ml measuring cylinder, followed by the addition of 100ml distilled water. The content was mixed thoroughly. The sediment volume was recorded after 3 hours when the level became constant.

4. Results and Discussion

Moisture Content

The *ogi* before and after drying is shown in figure 3. The moisture content of ogi produced from yellow maize (*Zea mays*) subject to different conditions in the Energy Storage Enhanced Multilayer Solar Dryer decreased with an increase in drying temperature and drying time (Figure 5). This is similar to the report of (Doymaz, 2005; Karim and Hawlader, 2005; Akpinar *et al.,* 2006; Kingsly *et al.,* 2007; Erenturk and Erenturk, 2007; Shi *et al.,* 2008; Bolaji *et al,* 2014). The moisture decreased significantly ($p<0.05$) for all drying temperatures. There were higher drying rates at high moisture contents (Fig 4). These decreased rapidly with decreased moisture content. The decrease in moisture content and drying rate (Figure 6) was non-linear, with an increase in the drying period and Drying temperature. This may be connected with the migration of water within the Ogi and the evaporation of moisture from Ogi into the air, as reported by Bolaji *et al.,* 2014.

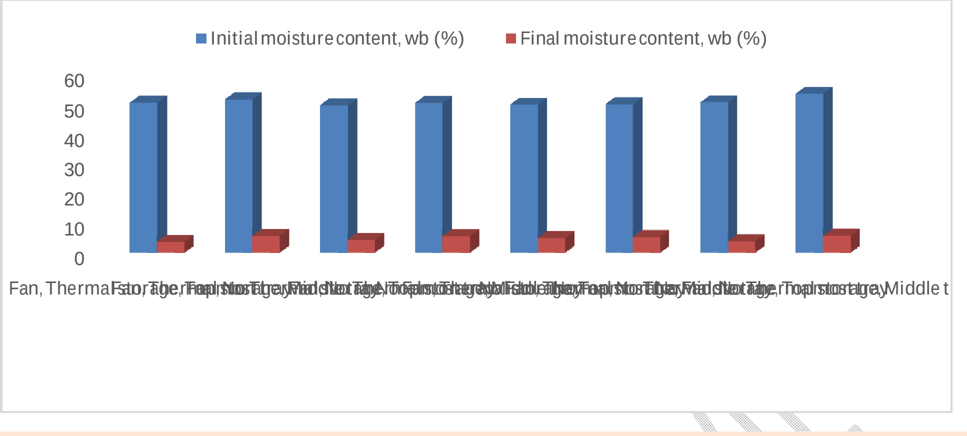

Figure 4. The initial moisture content (before drying) of *Ogi* and final moisture content (after drying) of *Ogi*

Bulk Density

The bulk density of the Ogi powders is presented in Table 1. The value of the bulk densities ranged between 0.64 and 0.76 g/cm^3. These are similar to the report obtained by Bolaji et al. (2014) and also similar to the report of Adegunwa et al. (2011). However lower when compared to durum wheat blends (Deng & Manthey, 2019). The variation in bulk density had been reported to be influenced by the quantity of starch and, most importantly, by the structure of starch polymers. The bulk density values were functions of both the density of powder particles and the spatial arrangement of particles in the powder bed (International pharmacopeia, 2012). The decrease in bulk density may help reduce transportation and packaging costs (Bolaji et al. 2014).

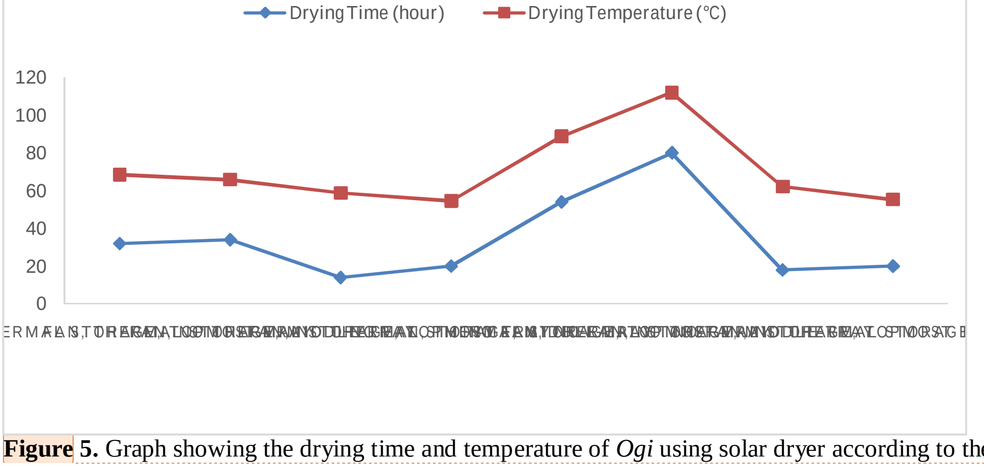

Figure 5. Graph showing the drying time and temperature of *Ogi* using solar dryer according to their variations

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pH of *Ogi*

The pH was examined in the range of 4.22 to 5.08, as shown in Table 1. The result obtained was similar to the report of Akintayo *et al.* (2020), who reported a range of 4.91 to 5.56, and also similar to a report by Frederick *et al. (0000)*, which recommends an equilibrium pH value of 4.6 or below as a safe pH for the preservation of finished product this is because, the lower the pH, the higher the level of acidity but slightly better than those gotten. The pH of the solar-dried *Ogi* reported was within the range of 4.6 to 5.1**.**

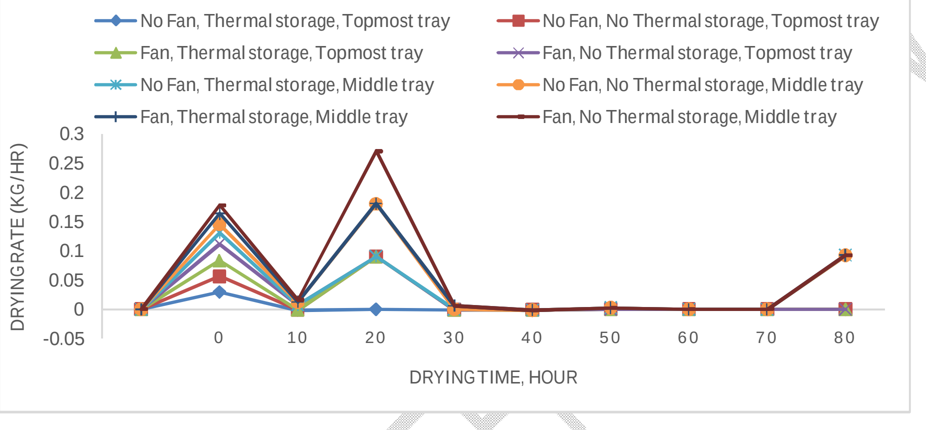

Figure 6. The rate of drying influenced by drying time of *Ogi*

Titratable acidity of samples

The titratable acidity of all the samples during fermentation ranges between 0.79 and 1.07 g/L lactic acid (table 2)**.** As shown in Table 2. The result obtained is similar to Bolaji et al., 2011. In this research, the *ogi* were stored at different temperatures, and the titratable acidity was reported to range between 0.8 to 1.0 (g/L). The higher titratable acidity indicates a better shelf-life and an inhibition of the activities of microorganisms (Bolaji et al., 2011).

Sedimentation Volume

Sedimentation is an important determinant of cooking quality (Bolaji et al. 2014). It was observed that the Sedimentation volume determined was within the range of 27.5 to 31.5, as shown in Table 1**.** This result is similar to that of Bolaji et al., 2014 it was reported in their research that good sedimentation volume ranges between 26 and 31 ml.

Table 2. The Physicochemical Properties of dried *Ogi* powder

Variation	Drying Time (hour)	Drying Temperature (°C)	Moisture content, wb (%)	Bulk density (g/cm3)	pH of Dried Ogi	Titratable Acidity (g/L)	Sedimentation Volume (Cm3)
Fan, Thermal storage, Topmost tray	32	36.38	3.63	0.73	5.06	1.05	27.5
Fan, Thermal storage, Middle tray	34	31.72	5.48	0.73	4.33	1.07	45
Fan, No Thermal storage, Topmost tray	14	44.69	4.17	0.72	4.22	1.03	35
Fan, No Thermal storage, Middle tray	20	34.5	5.4	0.64	4.78	1.05	30
No Fan, Thermal storage, Topmost tray	54	34.61	4.8	0.76	4.24	0.86	45
No Fan, Thermal storage, Middle tray	80	31.87	5.2	0.71	5.08	0.79	30
No Fan, No Thermal storage, Topmost tray	18	44.23	3.73	0.74	4.49	0.87	15
No Fan, No Thermal storage, Middle tray	20	35.18	5.59	0.72	4.72	0.96	35

Conclusion

The change in temperature and moisture content had a considerable impact on drying Ogi using the Energy Storage Enhanced Multilayer Solar Dryer (ESEMSD). When the drying temperature was raised, the drying time decreased. The amount of water removed was greater at the initial drying temperature. It was observed that the soaking duration had little effect on the *ogi's* physical characteristics. The amount of moisture in the drained *ogi* and the drying temperature was more closely related to drying behaviors.

Therefore, the Energy Storage Enhanced Multilayer Solar Dryer (ESEMSD), compared with other drying methods, can be an alternative, especially in locations with limited access to electricity, to ensure food preservation and encourage a large production of *ogi* that meet human satisfaction.

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