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Research Paper

Effect of drying temperature on physical properties of fermented dried locust bean flour

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Abstract. Drying plays a major role in food processing as it reduces the activities of micro-organisms and hence preserve food from deterioration. It has been reported that drying imposes new changes to the physical properties of the product which may in turn affect its handling, packaging and usability. The present research work, therefore aimed to evaluate the effect different drying temperature on physical properties of fermented dried locust bean flour. The local fermented locust bean was dried at different temperature of 50, 60, 70, 80 and 90°C at airflow rate of 1.8 kg/min. then milled and Investigated on final moisture content, bulk density, water retention ratio, flour wetting time, and swelling capacity of the fermented dried locust bean flour. The effect of drying temperature was found to be significant ($p \leq 0.05$) on all the physical properties investigated except bulky density (0.638 g/ml). As the drying temperature increased from 50 to 90°C, final moisture content decreased significantly from 5.62 to 3.52%. Whereas, water retention ratio, wetting time, swelling capacity, porosity ratio and water retention ratio increase from 1.96 to 2.5 m/g, 153 to 299 s, 2.26 to 2.44, 0.81 to 0.91 and 1.96 to 2.5 m/g respectively. These findings could prove useful in the modeling of locust bean drying and to flour millers and pelletizer who may want to use locust bean flour as a sole or composite flour for different production and application.

Keywords: Fermented locust bean flour, physical properties, modeling, pelletizer, miller, drying temperature, final moisture content.

INTRODUCTION

Background information

African locust bean *Parkia biglobosa* is a perennial deciduous leguminous tree with pods ranging from pink brown to dark brown in colour, when matured. The seeds are hardcoated and can remain viable for about 8 years (Sina *et al*., 2002; NRC, 2006; Orwa *et al.*, 2009). The pods are reported to contain up to 30 seeds embedded in a yellow pericarp. The seeds having a mean weight of 0.26 g/seed have a hard testa with large cotyledons forming about 70% of their weight. Locust bean is well known for its high commercial values as food and medicinal agent. The most popular form of consumption of African locust beans is in its traditional fermentation tasty food condiment called *dawadawa* by Hausa in the northern part of Nigeria and 'iru' by Yoruba people of western Nigeria which is used as a flavour intensifier for soups and stews and also adds protein to a protein-poor diet (Campbell-Platt, 1980; Ikenebomeh and Kok, 1984; Odunfa, 1986; Dike and Odunfa, 2003). The plant is among some highly reputed plant in the African sub region with an outstanding protein quality and amino acid composition which has been reported by several researchers (Cook *et al*., 2000; Alabi *et al*., 2005; Elemo *et al*., 2011).

The World Health Organization has reported a high presence of malnutrition level among the rural duelers in Africa. The most common form of malnutrition in Africa is protein energy deficiency affecting over 100 million people, especially 30 to 50 million children under 5 years of age (Jildeh *et al.*, 2010). The seed has been recommended for patient with deficiency in vitamin A, and some minerals (Shi, 2000). The main interest in this *Parkia biglobosa* tree is the use of its fermented seeds which has been reported to contain about 30 to 40% protein, 10 to 15% carbohydrates, 15 to 20% fat and 4% minerals (Codjia *et al*., 2003).

The continuation of the fermentation in the seed product after production must be controlled or stopped in other to prevent further microbial growth which can leads to spoilage. It has been observed that the fermented seed product produce bad odour and difficult to preserved after production. Salting techniques has been used by traditional people to preserve the product but was found to be ineffective and not readily accepted by people. It is therefore mandatory to investigate a more hygienic and modern method of drying the product. This can be achieved by drying and preserved in powder form which in turns can be pelletized inform of magi (a popular soup condiment). It has been reported that utilization of flour depends on its functional properties like, moisture content, bulky density, wettability, porosity etc. (Adeleke and Odeleke, 2010). The present study aimed at comparative studies on functional properties of fermented locust bean flour dried at different temperature.

MATERIALS AND METHODS

The fermented bean seed (*P. biglobosa*) used for the research was purchased from local markets in Iluju market, Ogbomoso, Oyo state, Nigeria. The experiments were performed in the following steps:

Sample preparation

The sample purchased from the market was mixed together and divided into different samples of 250 g each. The samples were place in thin layer on different drying trays and dried in the oven at 50, 60, 70, 80 and 90°C respectively. This experiment was designed to investigate the effect of drying temperature on some physical properties of locust bean flour. After the drying of each sample at selected temperature, the samples were milled using attrition mill, sieved to obtain fine powder and sealed in a selophine linoen and used the drying temperature for labelling it in preparation for further investigation on their physical properties.

Determination of physical properties

The properties determined from the samples were bulk density, porosity ratio, wettability, swelling capacity and water retention ratio.

Moisture content measurement

The moisture content of the flour was determined by using the method of American Association of Cereal Chemist (AACC), (2016). Five grams of dried fermented locust bean flour was kept in an oven at a temperature of 105°C for 1 hour. The sample was weighed again at the end of the period to determine its final weight. This experiment was replicated five times and the average weight was recorded. The moisture content given by the relationship:

$$Mc = \frac{(W_i - W_f)}{W_i} \times 100 \qquad (1)$$

Where, M_c is moisture content
W_i is initial weight and
W_f is final weight

Determination of bulk density

The bulk density of the flour was determined using a method which has been used by Idowu (2008) for cassava and Idowu *et al.* (2014) used for plantain flour. The procedure involves weighing 10 g of sample into a 50 ml graduated measuring cylinder. The sample was packed gently by tapping the cylinder on the bench top ten times from a height of 5 cm. The volume of sample occupied in the measuring cylinder was recorded and the bulk density calculated as follows:

$$\rho_b = \frac{W_t}{W_t} \qquad (2)$$

Where, ρb is bulk density (g/ml);
W_t is the weight of tapped sample (g); and
V_t is the volume of tapped sample (ml)

Determination of porosity ratio

The porosity of the flour was determined using a method which has been reported by Idowu (2008) for cassava and Idowu *et al.* (2014) for plantain flour. 10 g of the flour was made to pass through a well powdered sample of 0.5 mm micron. The volume of water that passes through the ground sample was used to calculate the % Porous using the formula:

$$P = \frac{w_W}{w_O} \qquad (3)$$

Table 1. Effect of drying temperature on some physical properties of locust bean flour.

Sample	Temperature (°C)	Moisture content	Bulk density (g/ml)	Porosity Ratio	Water-retention ratio (g/ml)	Wetting time (s)	Swelling capacity
1	50	4.62	0.64	0.81	2.22	153	2.26
2	60	4.42	0.63	0.82	2.22	208	2.31
3	70	4.06	0.63	0.83	2.08	258	2.32
4	80	3.59	0.63	0.84	2.08	262	2.35
5	90	3.52	0.63	0.87	1.96	300	2.44

Where, P is the porosity;
W_w is the weight of water recovered (g); and
W_o is the original weight of water applied (g)

Determination of water retention ratio (W_{RR})

The water retention ratio was determined using Idowu (2008) method which has been reported by Idowu *et al.* (2014). The locust bean flour sample (10 g) was added to about 10 mm distilled water in a glass beaker and stirred. Then the sample was drained on a filter paper for 30 min and the retention ratio of the locust bean flour was calculated and expressed as: weight of soaked flour per weight of the dried flour:

$$W_{RR} = \frac{W_s}{W_d} \tag{4}$$

Where, W_{RR} is the water retention ratio;
W_s is the weight of soaked flour sample; and
W_d is the weight of dried flour sample

Determination of swelling capacity

This was determined on the basis of volume. The swelling capacity was determined using the method which has been reported by Idowu *et al*. (2014). A 20 g of the sample was weighed into a cleaned calibrated measuring cylinder and 80 ml of distilled water was added and mixed quickly and carefully to eliminate air bubbles. It was allowed to settle quickly and the volume was noted and recorded:

$$S_c = \frac{V_f}{V_i} \tag{5}$$

Where, S_c is the swelling capacity;
V_f is the final volume (ml); and
V_i is the initial volume (ml).

Determination of flour wetting time

Wettability of the flour was estimated by measuring the wetting time in seconds of 10 g of sample powder from the height of 15 mm on the surface of 200 cm^3 distilled water contain in 250 cm^3 measuring cylinder at room temperature (°C). The wetting time regarded as the time required for all the powder to become wet and penetrate the surface of distilled water.

RESULTS AND DISCUSSION

Effect of drying temperature on some physical properties of locust bean flour

The results of the experiment showed that drying temperature influenced the selected physical properties of the flour (Table 1).

Effect of drying temperature on moisture content of the locust bean flour

The result of the experiment on the effect of temperature on moisture content of locust bean flour is as represented in Figure 1. This result shows that the drying temperature is inversely proportional to the final moisture content. As the drying temperature increases from 60 to 90°C the final moisture content decreased from 5.62 to 3.52% which is about 37.19% decrease. It was observed that the percentage moisture content of locust bean flour is higher (4.62%) when dried at 60°C. when compared to that of tiger nut flour (3.78%) as reported by Oladele and Aina (2007), but in agreement with the result of locust bean (Ijarotimi, 2012) which is 4.1%, and in the range reported for wheat and potato-wheat composite flour which is between 2.60 and 3.68% (Adeleke and Odedeji, 2010). The final moisture content of the dried fermented locust bean was between 3.2 and 5.73% db which is within the acceptable moisture limit of dry products (15%) as reported (Adeleke and Adedeji, 2010). The mathematical relationship between the drying temperature and the final moisture content is expressed using the regression (Equation 6):

$$M_C = 0.1579\, D_T{}^2 - 1.4561 D_T\; + 6.88\; R^2 = 0.982 \tag{6}$$

Where, M_c is final moisture content (% db); and D_T is Drying temperature (°C).

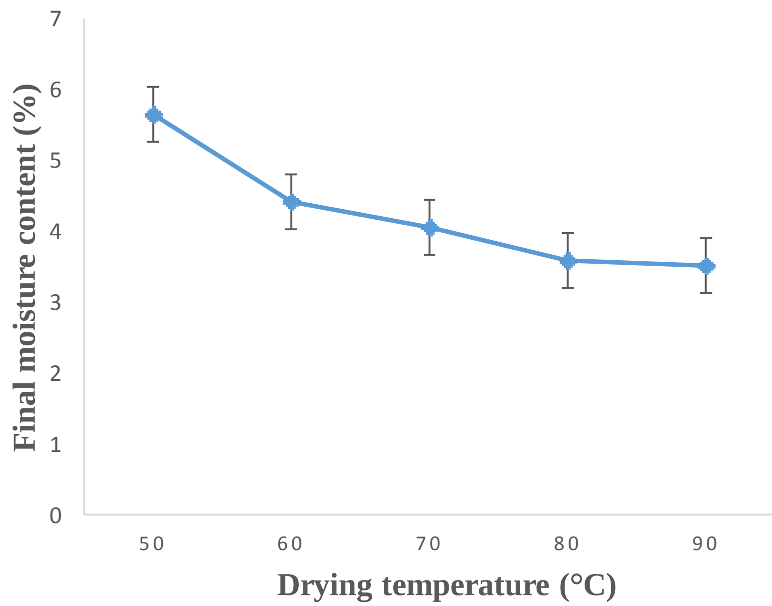

Figure 1. Effect of drying temperature on final moisture content of dried fermented locust bean flour.

Determining moisture content is an essential first step in analyzing flour quality since this data is used for other tests. Flour millers adjust the moisture in flour to a standard level before milling and mixing. Moisture content of 14 percent is commonly used as a conversion factor for other tests in which the results are affected by moisture content. Moisture is also an indicator of grain storability. It has been reported that flour with high moisture content (> 14.5 percent) attracts mold, bacteria and insects, all of which cause deterioration during storage and that flour with low moisture is more stable during storage. The lower final moisture content (below the 14.5%) of dried fermented locust bean would be an advantage during processing because of its stability.

Effect of drying temperature on bulk density

The result of drying temperature on bulk density as presented in Table 1 showed that the effect of drying temperature was significant ($p < 0.05$) on the bulk density. Based on this experiment, the bulk density of locust bean flour (0.638 g/ml) is higher than that of cassava flour (0.33 g/ml) as reported by Idowu (2008) and coconut flour (317.39 kgm^3) reported by Musuvadi *et al.* (2015), but same range of 0.797 g/mg as reported for fermented locust bean (Ijarotimi, 2012) and 6.83 g/ml for sweet potato flour (Kartuna *et al*., 1998) but a little lower than that of wheat flour (0.71 g/ml) as reported by Akubor and Badifu (2004). The effect of drying temperature was found to be insignificant ($p < 0.05$) on bulk density.

Bulk density has been described as the measure of heaviness of flour (Adejuyitan *et al.*, 2009). It has also been reported that bulk density is useful during blending of different flour and also in fortification with other useful ingredients (Nelson-Quartey *et al*., 2007). Since the bulky density is in the same range with some notable flours, its blending with other flours will be easy. The moderate bulk density of the flour will be used during packaging and transportation of the product.

Effect of drying temperature on water absorption capacity

The result of the effect of drying temperature on water retention ratio is shown in Figure 2. It was observed that water retention ratio increases from 1.96 to 2.5 m/g (increase of 30.6%) when the drying temperature was increased from 50 to 90°C. The result was in the range reported by Idowu (2008) for cassava flour (1.56) and 2.11 reported by Ijarotimi 2012 for locust bean flour, 1.7 m/g for African yam bean (Eke and Akobundu, 1993) and 1.68 to 2.21 for composite flour made from cassava and wheat flour (Camel *et al*., 2019) but lower than 3.4 m/g reported for canophor flour (Odoemelan, 2003).

The mathematical relationship between the drying temperature and the water absorption is expressed using the regression (Equation 7):

$$W_{RR} = 0.0157\, D_T^2 - 0.2323\, D_T + 2716 \quad (R^2 = 0.9829) \qquad (7)$$

Where, D_T is drying temperature (°C); and W_{RR} is water retention ratio

Water absorption capacity of flour is a useful indicator of the possibility of protein inclusion in aqueous food formulations (Osungbaro *et al*., 2010). The present result

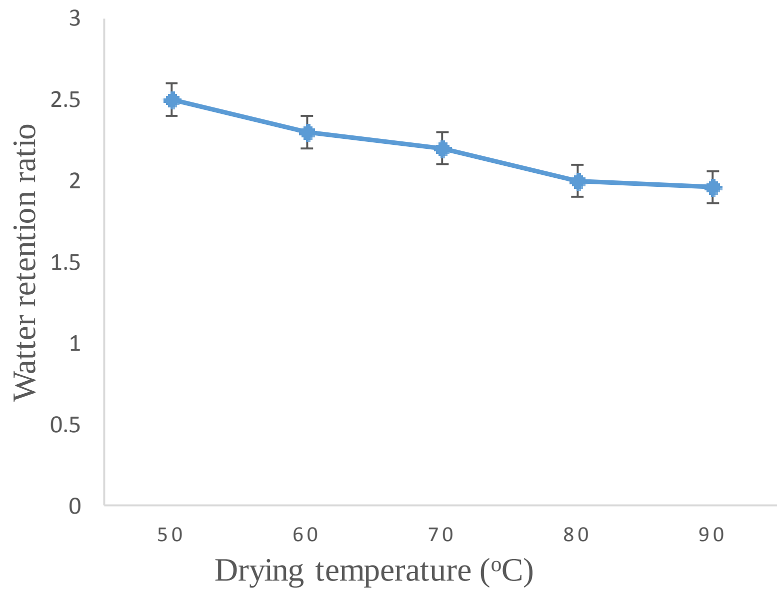

Figure 2. Effect of drying temperature on water retention ratio.

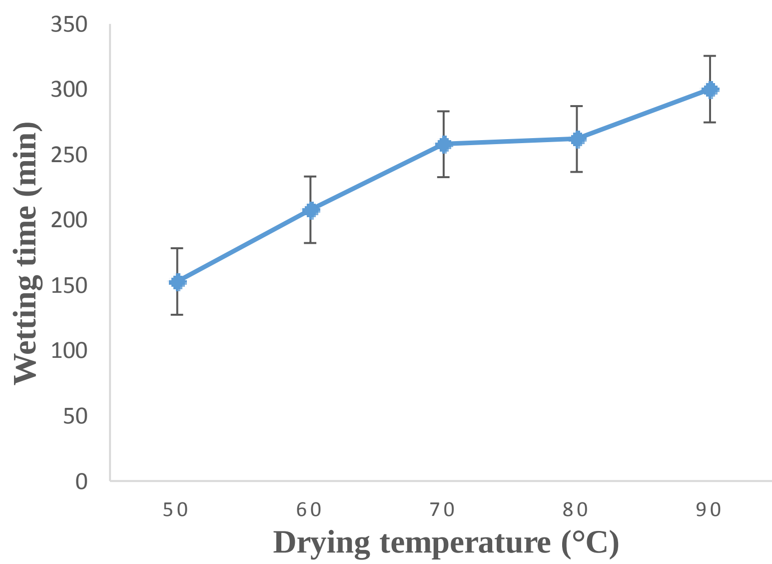

Figure 3. Effect of drying temperature on wetting time of dried fermented locust bean.

shows that the flour could be used in pelletizing food condiment and also suggests its utility in soup formulations.

Effect of drying temperature on wetting time

The results of processing temperature on wetting time are shown in Figure 3. The wetting time increased from 153 to 299 s (which is 95.4% increase) when the drying temperature increased from 50 to 90°C. This result shows that the wetting time reported for locust bean flour is lower than 231 s reported for plantain flour (Idowu *et al*., 2014). The drying temperature was found to be significant ($p < 0.05$) on wetting time.

The mathematical relationship between the drying temperature and wetting time is expressed using the regression (Equation 8):

$$W_t = - 5.7143D_T^2 + 69.086D_T + 91.91.8 \ (R^2 = 0.9721) \quad (8)$$

Where W_t is wetting time (s); and D_T is Drying

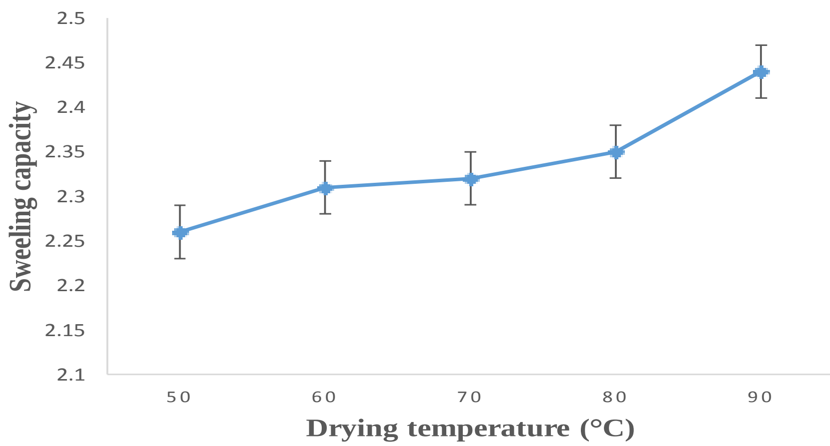

Figure 4. Effect drying temperature on swelling capacity of the flour.

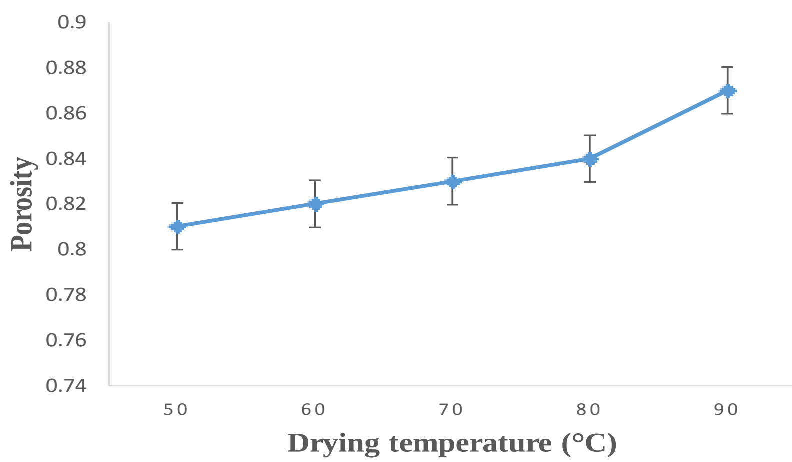

Figure 5. Effect of drying temperature on porosity ratio of the dried fermented locust bean flour.

temperature (°C).

Effect of drying temperature on swelling capacity

The swelling capacity of dry fermented locus bean flour was found to increase from 2.26 to 2.44 when the temperature increased from 50 to 90°C (Figure 4). The single factor ANOVA that was performed on the experimental results showed that the effect of drying temperature was not significant ($p < 0.05$) on swelling capacity of the flour. The swelling capacity was within the range (2.16) reported for cassava flour (Idowu, 2008) but lower than (8.72) that was reported for *Artocarpus altilis* pulp flour (Appiah *et al*., 2011) and between 8.75 to 13.42 g/g reported for cassava and wheat composite flour reported by Camel *et al*. (2019) .

The mathematical relationship between the drying temperature and swelling capacity is expressed using the regression (Equation 9):

$$S_{wc} = 0.0071\, D_T{}^2 - 0.0029\, D_T + 2.266\ (R^2 = 0.9432) \quad (9)$$

Where, S_{we} is swelling capacity; D_T is drying temperature (°C)

The low water absorption capacity will be useful in the selection of handling, packaging and storage equipment.

Effect of drying temperature on porosity ratio

The result of drying temperature on porosity ratio of dried fermented locust bean is shown in Table 1. It was observed that the porosity ratio of locust bean flour increased from 0.81 to 0.91 as the drying temperature increases from 50 to 90°C (Figure 5). The effect of drying temperature on the porosity ratio of dried fermented locus bean flour was found to be significant ($p < 0.05$).

The mathematical relationship between the drying temperature and porosity ratio is expressed using the regression (Equation 10).

$$P_r = 0.0029\, D_T^2 - 0.0031\, D_T + 0.812\ (R^2 = 0.784)\ (10)$$

Where, P_r is porosity ratio; and D_T is drying temperature (°C)

CONCLUSIONS

The analysis of the results obtained from the present experiment shows that the effect of drying temperature was significant on the physical properties of the flour investigated except bulk density. In view of above findings, it is, therefore, recommended that the drying temperature should be taken into consideration when the dried fermented locust bean flour is to be used either as main flour, as condiment, pellets or as a component of composite flours.

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