Development of a Locust Bean Fermentation Bin

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Abstract

Locust bean is an important food condiment in Africa; it is rich in protein, carbohydrates, fat, and oil. Fermentation of the cooked bean (which is carried out traditionally) is one of the major and the last operation in the processing of the seed to obtain the condiment. A fermentation bin for fermenting locust beans was designed, fabricated, and evaluated in this study. The fermentation bin simulated the principle of the traditional fermentation operation by enhancing the conditions necessary for the complete fermentation of locust beans. The bin consists of an inner chamber (made of stainless steel) where fermentation takes place, the lagging material (made of fibreglass) to prevent heat loss in the closed system, and the outer chamber (made of metal sheet) which serves as housing for the bin. The bin was evaluated based on locust bean loading (2, 4, 6, 8, 10, 12, 14, and 16 kg) and the time (48 hours), which was kept constant throughout the experiment. The results showed that an increase in the mass of locust beans in the fermentation bin led to a reduction in the overall rating of the output. For the above-listed loading of locust bean, the efficiency of the fermentation bin was 80%, 80%, 70%, 70%, 60%, 60%, 30%, and 20%, respectively. This result provides an insight into how to improve the efficiency of the device.

Keywords: Locust bean, sensory analysis, fermentation operation, fermentation bin

Research article
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1. INTRODUCTION

African locust bean (*Parkia biglobosa*) is common around villages in the Savannah areas of West Africa where it is left standing when land is cleared or sometimes planted and trees are individually owned (Dalziel, 1937). It is popular for the production of soup condiments (Akande et al., 2010). Fermented legumes, oilseeds, and nuts are commonly used in condiments. Some examples are *iru* from the locust bean, ogiri from the castor seed, and soy sauce from the soybean. *Iru* or *dawadawa* is a condiment used in many African dishes especially in Nigeria. The African locust bean and dawadawa are particularly useful sources of protein to the poorer sections of the community (Campbell, 1980). Locust beans are commonly found in Tropical Africa and the Mediterranean. It was estimated that about 200,000 tonnes of Africa locust beans seeds are gathered each year in Nigeria alone, as well as large quantities are produced in the savannah region of Southwest, Nigeria (Diawara, 2000).

In addition, a large quantity is produced in the savannah region of West Africa. More than 100 million people in West Africa use *iru* as a foodstuff (Odunfa, 1981). All parts of the crop are useful. It is used as a food condiment and it is a good substitute for meat, Maggi, and all other canned seasonings because it is high in protein, fat, and vitamins and it is rich in tannin and mineral content. The pods are used for the production of locust bean gum. This gum is used around the world as a thickening agent and stabilizer in many food products such as mayonnaise and within the textile industry as a print thickener (Glasson Grain Ltd, 2006). The fermented bean pulp waste contains protein 11.75 %; ash, 15.86 %; crude fiber, 21.55 %; starch, 32.14 %; dry matter, 93.5% and moisture, 6.5 % while the unfermented pulp contains protein 10.13 %; ash content, 14.14%; crude fiber 22.63%; starch, 28.20%; dry matter, 92.5% and moisture, 7.5%. The unfermented locust pulp waste exhibited a stronger binding effect than corn starch after 12 weeks of storage (Akegbejo-Samsons, 2004). Traditional boiling is carried out for cooking the beans with the hull for 8 to 10 h using firewood as fuel (Oyewole and Odunfa, 1990). After cooking, fermentation operation is carried out with the use of a basket and plantain leaves compacted in an enclosed system. The bean being fermented is left for 48 hours after which a sweet smell is perceived from the compacted enclosed system indicating the end of fermentation.

2. MATERIALS and METHOD

2.1. Description of the fermentation bin

The fermentation bin simulates the traditional way of enclosing the cooked bean in a controlled system, whereby a basket, cloth, or banana leaf is used to create the enclosure. This stage is important because it’s the last stage that precedes the finished product. The design as shown in Figure 1 consists of an inner chamber, the lagging material, and the outer chamber. The inner chamber makes up the fermentation bin; this is where the dehulled locust bean seeds to be fermented are placed. The inner chamber is made up of cylindrical stainless steel to accommodate the locust bean. The lagging material is made up of fibreglass placed in-between the inner and the outer chamber to conserve the heat required. The outer chamber is made up of sheet metal to form the body of the fermentation bin. The external section makes up the housing chamber that insulates around the internal chamber as shown in Figs 2 and 3.

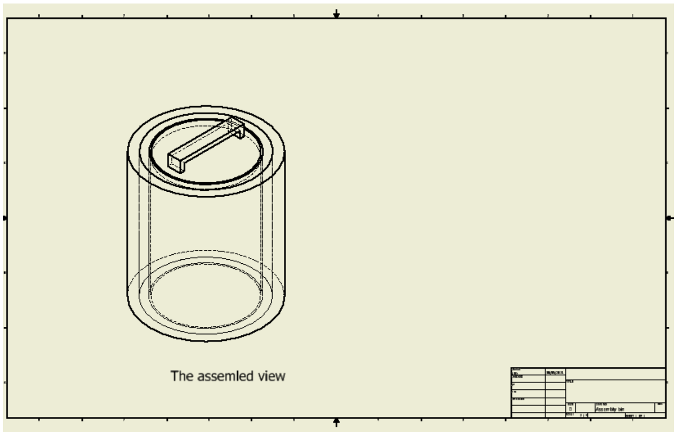

Figure 1. CAD design of the fermentation bin

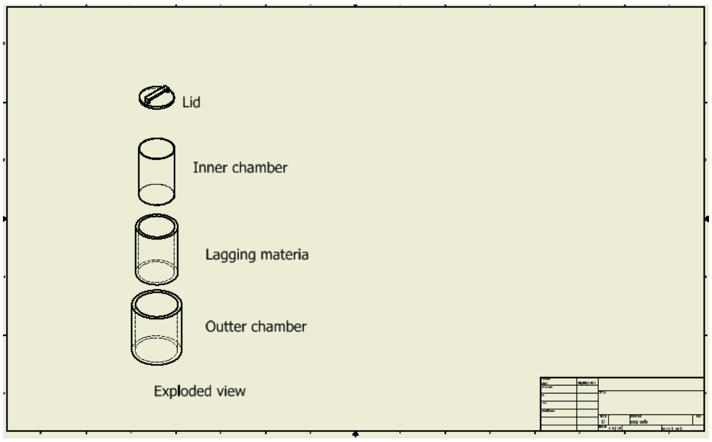

Figure 2. Exploded view of the fermentation bin

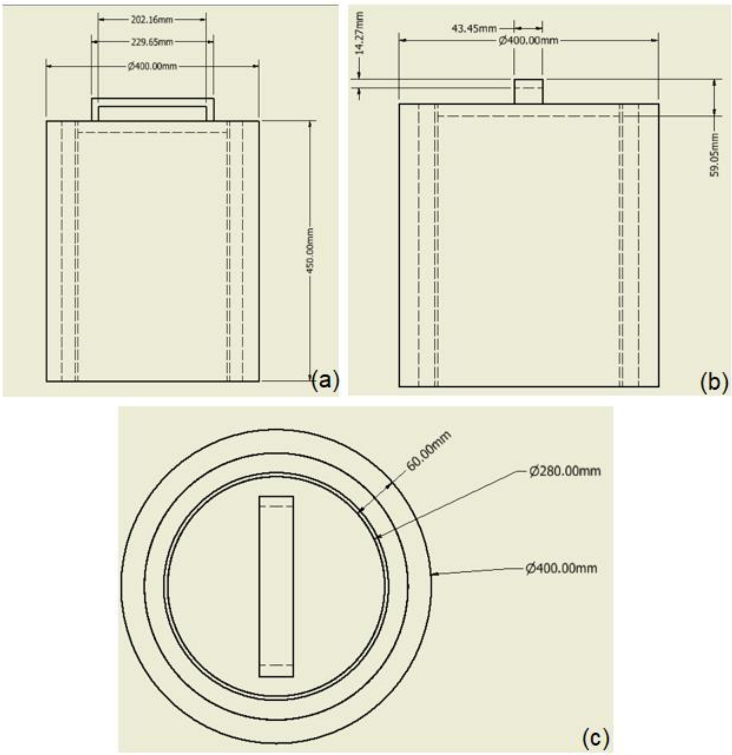

Figure 3. (a) Front view, (b) Side view, (c) Plan view

Figure 4. Fabricated fermentation bin

2.2. Specification of the Component Parts of Bin

The parts of the device and the materials used for their fabrication are shown in Table 1. Stainless steel was selected for the inner chamber because of its non-corrosive nature, due to the high moisture present in the parboiled locust bean it can corrode ordinary metal hence the need for stainless steel at the inner chamber, fibreglass was selected as a lagging material due to its ability to absolve heat and prevent heat loss and, mild steel was chosen for the outer chamber due to its ability to resists corrosion.

Table 1. Material Selection for the Design of Fermentation Bin

Parts of the devices	Materials of construction	Specifications
Lid Inner chamber	Mild steel Stainless steel	59.05 x 280 mm 450 x 280 mm
Lagging material	Fibreglass	450 x 60 mm
Outer chamber	Mild steel	450 x 400 mm

2.3. Design of the inner chamber

The inner chamber which determines the volume of the fermentation bin was designed based on the data obtained from the literature. The bulk density of locust beans is 538.02 kg/m^3 (Ogunjimi et al., 2002). For the maximum load of locust bean expected to fill the fermentation bin, the volume, height, and diameter of the bin were determined as follows.
Using 16 kg of a locust bean seed.

$$\text{Density } (\rho) = \frac{Mass\ (m)}{Volume\ (v)} \quad (1)$$

$$\text{Volume} = \frac{Mass\ (m)}{\text{Density } (\rho)} \quad (2)$$

$$\text{Volume of locust bean seed} = \frac{16}{538.026} \quad (3)$$

$=0.029\text{m}^3$

$$\text{Recall; Volume} = \pi r^2 h \quad (4)$$

The height is calculated from formula 4 as:

$$\text{Height} = \frac{volume}{\pi r^2} \quad (5)$$

$h = 0.45\text{m}$

The radius is calculated from formula 4 as:

$$r^2 = \frac{volume}{\pi h} \quad (6)$$

$$r = \sqrt{\frac{volume}{\pi h}} \quad (7)$$

r=0.14m=14cm

Therefore, the height of the fermentation bin required to process a 16 kg locust been was found to be 0.45 m with a diameter of 0.14 m.

2.4. Analysis of heat transfer across the walls of the fermentation bin

Each section of the fermentation bin wall behaves as a composite wall (Fig.4). Firstly, the temperature of the fermentation chamber after being filled appropriately with boiled dehulled locust bin is designatedT_{s1}. The heat as a result of the temperature circulates by radiation and convection on the internal stainless steel. The heat is transferred by conduction through the stainless steel wall to T_{s2}. The heat is transfered through a distance of L_A to the lagged material and then through L_B by conduction in the fibreglass from T_2 toT_3, to the external mild steel and by a distance of L_C heat is lost to the surrounding environment as shown in Fig 4. Heat lost to the environment from the external mild steel is by convection and radiation.

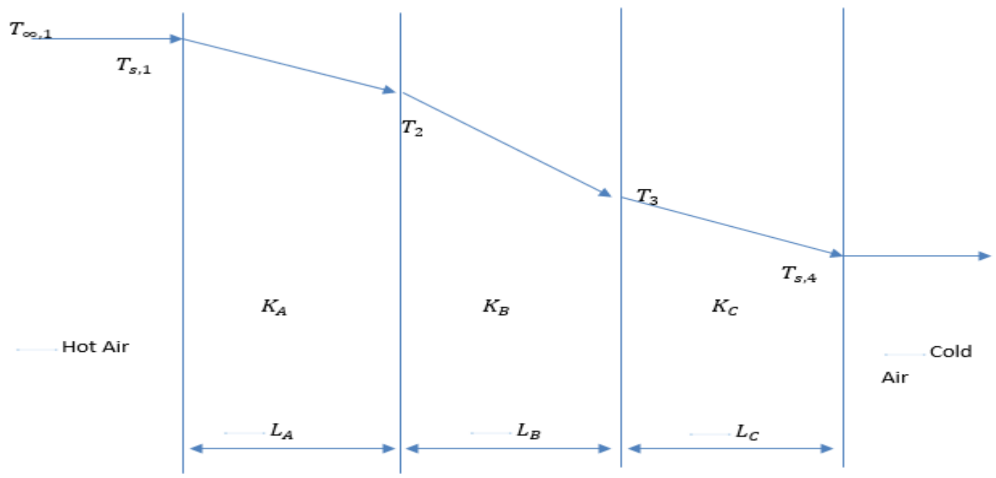

Figure 4. Graphical representation of heat transfer in the fermentation bin

2.5. Performance evaluation of the fermentation bin

The cooked locust bean was loaded in the inner chamber at different loading rates (2, 4, 6, 8, 12, 14, and 16kg), covered, and left for 48 hours. At the end of 48 hours, the condiment brings out a sweet smell indicating the process is completed.

To evaluate the quality of the fermented locust beans and the performance of the fermentation bin, ten (10) member panellists were selected (Sadiku, 2010) to carry out a sensory evaluation. These members consist of workers and staff of different eateries on the Obafemi Awolowo University campus; they were selected based on their experience and familiarity with locust beans. Parameters used in accessing the quality include aroma, colour, appearance, and mouthfeel. Their opinions were collated and analysed and their judgment was based on a standard scale Table 2.

3. RESULTS and DISCUSSION

The result obtained from the fermentation of the locust bean (Table 2) shows that fermentation is affected by the loading mass. The perception of the panellist revealed that the fermentation of the locust beans was done appropriately and pleasingly to taste except for loading of 14 and 16 kg. This result obtained for 14 and 16 kg is similar to the report of (Leito et al., 2006) who reported that a very high organic loading rate leads to a decrease in bioreactor performance due to disruption in microbial community structure.

Table 2. Physical quality assessment of the fermented locust bean.

Properties	**Samples**							
	2kg	4kg	6kg	8kg	10kg	12kg	14kg	16kg
Colour	3	3	1	2	1	1	5	5
Mouthfeel	3	3	1	1	1	1	5	4
Aroma	3	3	1	1	1	1	5	4
Appearance	3	3	3	3	1	1	4	5

Normal (1), Good (2), Very good (3), Bad (4), Very bad (5)

3.1. The effect of loading mass on the appearance of the fermented locust bean

Fig.5 shows the result of the physical quality assessment of the fermented locust bean. Loading the fermentation bin with 2 kg of locust bean gave an appealing appearance. However, there was a fluctuating increase in the appearance of the fermented locust bean as the loading mass increased until the load increased to 10 kg; the appearance was steady from 10 to12 kg

The phenomena declined when loaded with 14 and 16 kg. This implies that loading the fermentation bin with locust bean weight between 14 and 16 kg will give the locust bean an unfriendly appearance as a result of the decrease or disruption in performance due to disruption of microbial community structure in the fermentation bin (Leito et al., 2006)

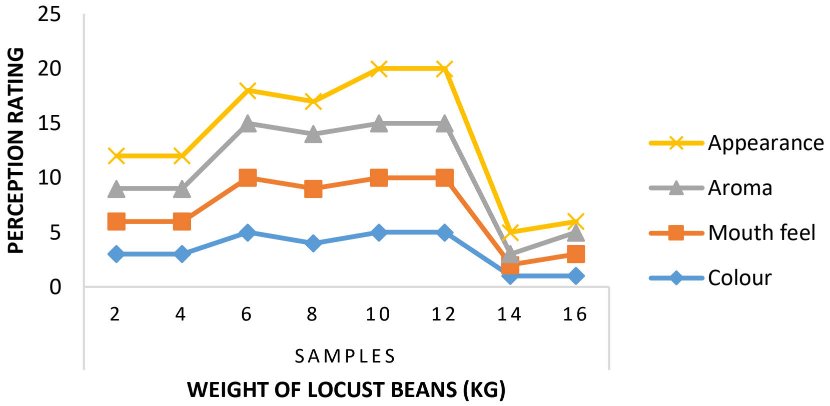

Figure 5. Graphical representation of the physical quality assessment of the fermented locust bean

3.2. The effect of loading mass on the aroma of the fermented locust bean

It was observed that 2 and 4 kg of the fermented locust bean produced a sweet aroma which is the expected characteristic of *dawadawa* aroma. Increasing the mass of the fermented condiment resulted in a slight increase in the perception of the aroma. The aroma was perceived to be less favourable as the mass of the fermented locust beans increased from 6 to 8 kg, while the aroma of 8 and 10 kg remained acceptable. This was similar to (Gernah et al., 2006) reports, starting that the characteristics of *dawadawa* aroma proceed out of the traditional fermentation when gmelina and banana leaves were used as fermentation material. However, loading the bin with 14 and 16 kg produced a bad aroma indicating that the bin at the specified geometry is ineffective when loaded with locust bean more than 12 kg (Fig 5). This is also similar to (Leito et al., 2006)] report on the ineffectiveness of a bioreactor when overloaded.

3.3. The effect of loading mass on the mouthfeel of the fermented locust bean

The trend of the analysis of the acceptability of the fermented locust bean based on mouthfeel is similar to other sensory test parameters considered for this study (Fig 5). When experimenting with the effectiveness of the fermentation bin with respect to the mouthfeel, it was observed that 2 and 4 kg samples of the condiment produced the best mouthfeel. However, compacting the locust bean in the fermentation bin up to 10 kg gave a good mouthfeel. The assertion is similar to mouthfeel is similar to the report of (Sadiku, 2010) who reported a sweet mouthfeel for fermented locust bean when fermentation was carried out properly therefore, recommending the control method as the best for fermentation. Any attempt to increase the load inside the fermentation bin beyond 12 kg resulted in poor taste. Hence, for an optimal feel of taste, the fermentation bin could be loaded with locust beans was between 10 to 12 kg.

3.4. The effect of loading mass on the colour of the fermented locust bean

Generally, the colour of the fermented locust bean does not appeal to all the observant (Fig 5). Conversely, it was preferred in some circumstances. The colour of the fermented locust bean is less appealing when the bin was loaded with 14 and 16 kg. It gave a cool brown colour when loaded with 2 and 4 kg of locust bean.

Moreover, the colour appears better when loaded with 6, 10, and 12 kg, respectively. The fermentation bin produced locust beans that maintained a stable colour with 10 and 12 kg of loading mass. This also implies that an effective colouration could be obtained with the fermentation bin when the loading mass does not exceed 12 kg. The brown colour obtained is similar to the report of (Sadiku, 2010) in his steam sample experiment, which reveals that good fermentation brings about a creamy brown colour. Also, (Gernah et al., 2006) reported that when fermentation is carried out traditionally using gmelina and banana leaf, a brownish colour was observed.

3.5. Acceptability and overall rating of the fermented locust beans

From Fig.6, it is evident that the fermentation bin was able to produce good quality fermented locust beans that met human satisfaction. However, the condiment has highest the acceptance when it was processed with less compaction in the fermentation bin. This could be a result of the effective migration of heat within the fermentation bin. Overloading the bin with locust bean tends to reduce the effect of fermentation leading to rejection of the fermented locust bean. Similarly, Fig 7 showed that the product of the fermentation was disliked when the locust bean did not ferment as expected. This implies that any attempt to increase the mass of the product being fermented will always lead to poor performance of the device and a decline in the quality of the product. Since the product is expected to satisfy human beings, therefore, it is important to limit the application of the volume of the fermentation bin between 2 and 12 kg.

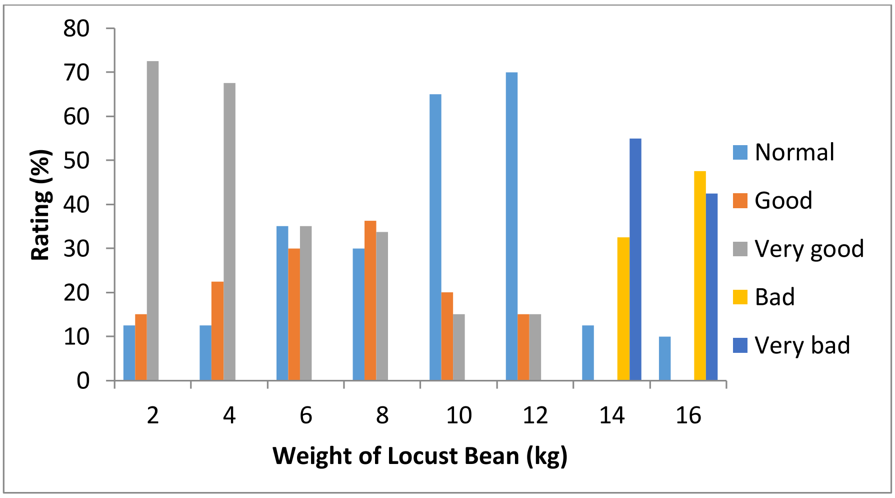

Figure 6. Graphical representation of the acceptability level

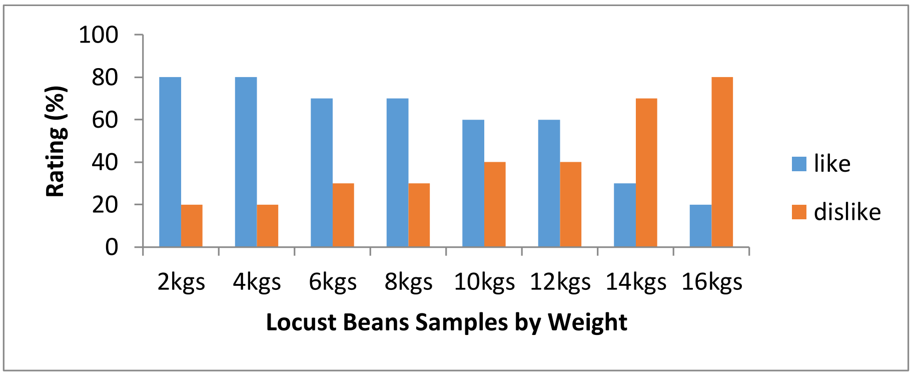

Figure 7. Graphical representation for the overall rating

4. CONCLUSION

It has been shown that the processing of locust bean into *Iru* will give very good and high nutritive quality if it is processed with the right device which simulates the traditional way of processing the condiment. It also shows that without the application of chemical substances as processing catalysts (like wood ash), additives, or preservatives, the condiment could be processed at a shorter time compared to the waiting time using the traditional approach. The fermentation bin performed better when the locust bean was not compacted. This allowed the migration of moisture and the circulation of heat required to facilitate fermentation and enhance the quality of the product. From the loading of 2 to 12 kg, the fermentation bin produced fermented locust beans with relatively better physical qualities than 14 and 16kg in terms of aroma, colour, taste, and texture. Since the bin simulates the traditional way of fermentation and performed better using a physical comparison and sensory evaluation approach.

Therefore, the fermentation bin is recommended to replace the traditional way of fermentation. The results obtained coupled with the desirable products of the bin as compared with the traditional way of fermentation will encourage large production of fermented locust beans and products that meet human satisfaction.

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