# Design And Construction of a Lateral and Non-Lateral Spacing Locust Bean Dryer

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**Abstract**

Locust beans has a lot of nutritional and medical benefits to the body but due to the stages of processing locust beans, it makes the farmer to produce minute portion of locust beans. This project work target at making locust beans available during season and out of season using a comparative analysis of lateral and non-lateral locust bean dryer. The locust bean dryer was designed and fabricated, the locust bean seed was procured, processed and allowed to ferment. Then, the locust bean was dried using lateral and non-lateral spacing locust bean dryer. Lateral and Non- lateral spacing locust bean dryer was compared. The optimum dryness of locust bean was achieved with average mass of moisture content lost for non-lateral spacing was 0.50kg. It was observed that has the temperature increases the time taken reduces. The optimum dried locust bean was achieved with average mass of moisture content lost for lateral spacing was 0.15kg. It was observed that it takes lesser time to achieve optimum dryness of locust bean with increases in temperature as samples were loaded. The suitable method is Lateral spacing locust bean dryer. The dried locust bean can be preserved for a longer period of time.

**Keywords**: Locust Bean dryer, Locust Bean, Lateral Spacing, Non Lateral Spacing.

## Introduction

Irú (Yoruba) or Eware (Edo) is a type of fermented and processed locust beans (Parkiabiglobosa) used as a condiment in cooking. Several constraints are identified in the production and consumption of the condiment. These include among others, low production due to the use of rudiment equipment, high wood consumption and poor manufacturing practices. Dehulling and cooking of the locust bean seeds are time consuming, laborious and inefficient. Consequently, the production of this condiment has not increased substantially. Its declining popularity, especially among the growing urban population has led to rapid increase in an import of foreign soup flavors [1]. Therefore, means is adopted to preserve and prolong the duration of locust beans using a lateral and non-lateral locust bean dryer.

Parkiabiglobosa, also known as the African locust bean or néré or dodongba, is a perennial deciduous tree of the Fabaceae family. It is found in a wide range of environments in Africa and is primarily grown for its pods that contain both a sweet pulp and valuable seeds. Where the tree is grown, the crushing and fermenting of these seeds constitutes an important economic activity. Various parts of the locust bean tree are used for medicinal purposes. As a standing tree, locust bean may have a positive effect on the yield of other nearby crops. Parkiabiglobosa is a dicotyledonous angiosperm belonging the family Fabaceae – Mimosoideae. It is categorized under spermatophytes, vascular plants. It is a deciduous perennial that grows to between 7 and 20 meters high, in some cases up to 30 meters. The tree is a fire-resistant heliophyte characterized by a thick dark gray-brown bark. [2] . The pods of the tree, commonly referred to as locust beans, are pink in the beginning and turn dark brown when fully mature. They are 30-40 centimeters long on average, with some reaching lengths of about 45 centimeters. Each pod can contain up to 30 seeds. [3] Most people detest the locust beans because of the unpleasant smell but unknown to them, locust bean is beneficial to its consumers.

The plant commonly referred to as Iru by the Yoruba speaking part of Nigeria. It is also known as Ogiri by the Igbo people of the country and Dawadawa by the Hausa people in Nigeria. Locust beans is also a local ingredient for soup and stew such Vegetable, Egusi, Ewedu, and so on. There are various health benefits that can be derived from locust beans which serves as economic importance and they are:

i. it contains nutrients like protein which build and repair tissues in the body, carbohydrate which is a source of energy to man's body.
ii. It also helps to fuel the brain, kidney, heart muscles and the central nervous system. Fat and calcium are also included in locust beans.

iii. Locust beans make vision clearer: Consumption of locust beans helps to give good eyesight to people who have eye problem such as cataract, minus eyes, myopia, glaucoma and the rest because it also contain natural nutrient that can maintain eye health
iv. Locust beans treat stroke: A stroke is a disruption of oxygenated blood to the brain. It is also usually associated with cholesterol and high blood pressure one of the most convenient way to treat the sickness is to consume locust beans regularly. (The Nation 2019)
v. Source of money to the farmer
vi. It helps to increase the Gross Development Product of the Nation through foreign exchange

Mohammed *et.al* (2018) worked on "Design, Fabrication and Testing of a Manually Operated Locust Bean Cubing Machine" [4] This research was undertaken to develop a locust bean cubing machine. The machine was designed to cube 2kg of fermented locust beans with the help of a piston-connecting rod arrangement, as a conveying mechanism. A handle attached to the connecting rod provides the drive and force required for cubing and the resultant piston speed was computed empirically. The results showed that the machine required a piston speed and pressure of 33 msec-1 and 25.1 kN m2, respectively. Also, the machine was able to produce cubed locust beans of an approximate size of 0.06 m2.

In the investigation made Farayola *et.al* (2012) on the "Economic analysis of locust beans processing and marketing in Ilorin, Kwara State, Nigeria" [5] The research work was designed to estimate the economic analysis of locust bean processing and marketing in Ilorin, Kwara State, Nigeria. Primary data was used and purposive sampling technique was adopted to select the respondents used for the study. A total number of 60 respondents were interviewed. The data collected were analyzed using inferential statistical tool such as regression analysis. Budgetary analysis technique was also used to analyze the profitability of locust bean processing and marketing in the study area. Majority of the processors and marketers are making profits; 68.3% operate above breakeven point while 26.7% operate at breakeven point and the rest 5% was below the breakeven point, this indicates that they neither profit nor lost.

The regression analysis result shows that quantity processed, family size and years of experience in processing are significant at 1%, 5% and 10% respectively while education level and stall rent is negative and significant at 1% and 5% respectively. F- Test also explained that independent variables are jointly significant at 1% probability level with an adjusted R2 of 78.9%. The overall rate of return on investment indicates that average rate of return is 0.5 (50%), which is positive.

Adejumo *et.al* (2013); "processing, utilization and challenges of african locust bean (parkiabiglobosa, jacquebenth)" [6] The study examined the processing, utilization and challenges of African locust bean (Parkiabiglobosa) in Arigidi Akoko in Akoko Northwest Local Government Area of Ondo State. A total of 3,446 locust bean sellers were identified and 5% of the sellers were sampled given the total of 172 respondents: 80 at Imo Arigidi, 50 at Arigidi Oja, and 42 at Agbaluku which are the three major settlements in the town. Data were collected using a structured questionnaire and subjected to descriptive statistical tools. The Socio-economic analysis shows that locust bean processing and trade are dominated by females (97.7%) with trace percentage of male (2.3%). This could be traced to preference of women in processing operations. The prevalent method of processing is manual or traditional.

Majority of the respondents (48.8%) believed the processing method is strenuous and it takes a lot of time. However 32% of the people considered it simple and less stressful but 2.3% perceived the activities to be simple, stressful and time-consuming. Similarly, 59.9% of the respondents only submitted that the processing method could be learnt while 57.6% of the respondents specified the number of days in which the processing method could be learnt (1-7 days).

Adamade *et.al* (2014) "Performance evaluation of a dryer for processed locust bean condiments" [7] Drying of fresh fermented locust beans condiments is highly important in marketing strategy. Performance test of the dryer for processed locust beans condiments (Iru) was carried out using an instrumented dryer designed and developed, this was used to dry two varieties of fermented locust beans (IruWoro of initial moisture content of 48.38 % and Iru Pete 49. 20 %) under three different temperatures (45 0C, 50 0C and 55 0C) for electric heater, 70 % average relative humidity and three categories of Weights (200g, 300g and 400g) and drying one hour interval. The moisture loss and drying rates were determined for the processed locust beans. The average drying rates ranged from 17.99 to 1.72g/hr and 14.32 to 31.76 g/hr for the Iru-Woro and Iru-Pete respectively. The efficiency of the dryer ranged from 65.71 % - 84.60 % for Iru-Woro and 65.60 % - 84.87 % for Iru Pete respectively. The drying rates and efficiency of the dryer were subjected to statistical analysis using 2 x 3 x 3 factorial design to study the effects of these parameters on the drying rates of the dried processed products. These results showed

a significant difference in the different varieties dried at 5% confidence level.

Aguwa *et.al* (2016) "Effectiveness of Locust Bean Pod Solution (LBPS) in the Production of Sandcrete Blocks for Buildings Department of Civil Engineering, Federal University of Technology, Minna, Nigeria" [8]

Locust beam pod solution (LBPS) was prepared by extraction from the outer leathery cover of the pod soaked in water for twenty four hours in ten different concentrations of known weight of dried locust bean pod cover in 20 litres of clean water. Using ten levels of these concentrations, five sandcrete blocks of size 150mm cube were produced for each concentration, making a total of fifty blocks and the compressive strengths at 28 days were determined. Using a concentration of 50g/l, twenty blocks were produced with 0, 5, 10, 15, 20, 25, 30, 35 and 40% respectively by weight of cement reduced making a total of 180 blocks.

They were subjected to compressive strength test on 7, 14, 21 and 28 days respectively, crushing five blocks in each day to determine their average compressive strength. In order to investigate the effect of duration of soaking the locust bean pod cover in water on the compressive strength of the sandcrete blocks, five blocks were produced using the same concentration of 50g/l but soaked in water for 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 days respectively and their compressive strengths were determined at 28 days. It was found that the higher the concentration of the LBPS, the more the compressive strength and soaking the locust bean pod cover for more than 24 hours is not necessary as the compressive strength tends to decrease. In conclusion, up to 25% by weight of cement can be saved by using locust bean pod solution in moulding the sandcrete blocks.

Akande *et.al* (2010) worked on "Processing of locust bean fruits: Challenges and prospects" [9] In their studies the traditional methods of production of fermented locust beans, the problems associated with it and the possible ways of overcoming these problems in order to bring this health friendly seed into the limelight of large scale production were reviewed. The processing of locust bean fruits to food condiment involves depodding, cleaning, boiling, dehulling, washing, re-cooking and fermentation. Some constraints are identified in the production and consumption of the condiment such as low production due to rudiment equipment, high wood consumption and poor production practices.

**Materials and Methodology**

**Design Consideration**

Stainless material was used to design the machine to prevent the corrosion which might affect the locust bean. Heat exchanger was used to transmit heat and prevent direct heat to the locust bea n to avoid burnt locust bean while drying. The tray surface area was reduced by placing mesh on the tray to hold the dried locust bean from dropping into the machine. The machine was placed in the direction of air to keep the charcoal burning. Coal pot was fabricated which bear the burning charcoal that serves as source of fuel to the machine.

**Components of Locust Beans Dryer**

**Heat Exchangers**

A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes.(Ahmed T. Al-Sammaraietal andKambizVafai 2017). The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.(Sadik Kakaç and Hongtan 2002) They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.(Salimpour et al 2019).

Figure 3.1 shows heat exchanger

Figure 3.1: Heat exchanger

**Trays**

A tray is a shallow platform designed for the carrying of items. It can be fashioned from numerous materials, including silver, brass, sheet iron, paperboard, wood, melamine, and molded pulp. Trays range in cost from inexpensive molded pulp trays which are disposable and inexpensive melamine trays used in cafeterias, to mid-priced wooden trays used in a home, to expensive silver trays used in luxury hotels. Some examples have raised galleries, handles, and short feet for support (https://en.m.wikipedia.org/wiki/Tray#cite_note-4)

Figure 3.2: Locust bean dryer tray

**Locust Bean Dryer**

It consists of a heating chamber which is filled with charcoal and charged by fire.

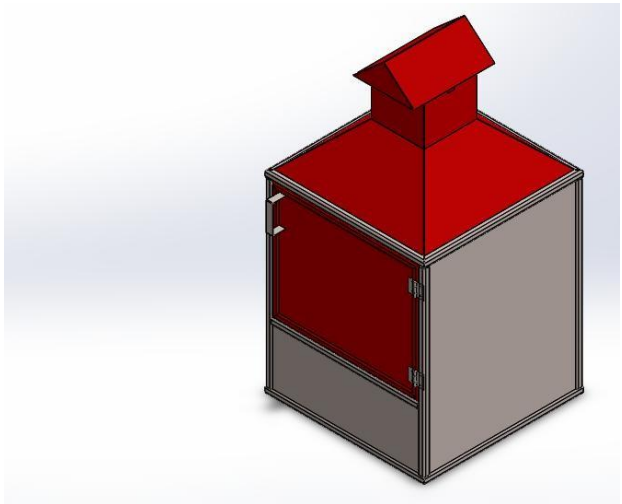

Figure 3.3: Locust bean dryer

**Thermocouple**

Thermocouple is used to measure the temperature of the locust bean dryer.

**Processing and Preparation of Locust bean**

i. Depodding of the locust bean fruits are mostly done by hand by the processors, though it has been concluded that threshing machine used for cowpea could be used for removing the locust bean seeds coated with yellowish pulp from the pod.
ii. The seeds of the locust bean are embedded in a yellowish pulpy material and seeds needed to be separated from this yellowish pulpy material before it can be further processed into fermented locust bean (food condiment).
iii. Cleaning of the locust bean seeds which have to do with removal of any foreign materials prior to further processing is still done manually by use of wind to winnow it or washing in water.
iv. Cooking of locust bean seeds; the bean is encased in a hard, tough and relatively thick coat that has semi-permeable characteristics.
v. Dehulling occurs when firmly attached seeds coats which has been softened during cooking is removed for fermentation process.
vi. Separation of locust bean cotyledon from its coat proceeds dehulling operation. This operation involves the use of local sieve in flowing water or inside a bowl of water to remove the hull from the locust bean cotyledon.
vii. Re-cooking of the dehulled seeds. The essence of re-cooking the dehulled seeds is to hasten fermentation process, using locally made aluminum cast iron pot and fire wood as source of heat.
viii. The production of fermented locust bean has remained a traditional family art practiced in homes with rudimentary utensils, such as calabash, clothes or leaves for covering to produce a strong-smelling food condiment/flavoring agent, this method is seen to be unhygienic and needs attention.

**Drying using Lateral and Non-Lateral Spacing Locust Bean dryer**

**Lateral Spacing Analysis of Locust Bean Dryer**

Lateral spacing can be defined as the allowance of space between the tray and the wall body of the machine which permeate the action of air and heat on the locust beans.

The locust bean dryer was washed and cleaned. Mesh was placed on the tray so that the locust bean could be contained. The locust bean dryer contained three trays and each tray was weighed using weighing balance. Coal pot was fabricated and weighed using weighing balance. Charcoal was

fired in coal pot. The locust bean was arranged on the trays leaving space at the sides of the trays. The trays was arranged into the locust bean dryer and the coal pot was placed inside the locust bean dryer. Charcoal is the fuel used to power the locust bean dryer. Stop watch was set to check the time taken to achieve drying and the result was recorded.

**Non-Lateral Spacing Analysis of Locust beans Dryer**

Non-Lateral Spacing could be defined as the reduction in space between the space and wall body of the locust bean such that the action of air and heat on the locust bean dryer is reduced.\

The locust bean dryer was washed and cleaned. Mesh was placed on the tray so that the locust bean could be contained. The locust bean dryer contained three trays and each tray was weighed using weighing balance. Coal pot was fabricated and weighed using weighing balance. Charcoal was fired in coal pot. The locust bean was arranged on the trays leaving no space on the trays. The trays were arranged into the locust bean dryer and the coal pot was placed inside the locust bean dryer. Charcoal is the fuel used to power the locust bean dryer. Stop watch was set to check the time taken to achieve drying and the result was recorded.

**Design Calculations**

**Volume of the Kiln**

Since the kiln takes a rectangular shape

The volume of a rectangle is Length × Breadth ×Height

Length= 610.0mm

Breadth= 740.0mm

Height= 260.0mm

Volume= LBH = 610 × 740 ×260= O.117$m^3$

**3.5.2 Volume of the charcoal tray**

The tray takes a rectangular shape.

The volume of a rectangle is Length × Breadth × Height

Length= 43.5cm=

Breadth= 46cm =

Height= 11.5cm=

Volume= Length*Breadth*Height

=

**Heat generated by the charcoal in respect to the mass of charcoal used**

H= mc

**Heat transferred by the charcoal in respect to the surface area of the charcoal tray**

Q= .$A.T^4$

Then, = 5.67 × $10^{-8}wm^{-2}$

**Results & Discussion**

**DIMENSIONS**

The dimension of the locust bean dryer components

Table 4.1.1 shows the weight of coal pot and trays

| DIMENSIONS | |
|---|---|
| | WEIGHT(Kg) |
| COAL POT | 2.3 |
| TRAY | 2 |
| | 3trays= 3*2= 6 |

Table 4.1.2 shows the linear dimensions of the coal pot and trays

| DIMENSIONS | | |
|---|---|---|
| | COAL POT(cm) | TRAY(cm) |
| LENGTH | 43.5 | 48.5 |
| BREADTH | 46.5 | 46 |
| HEIGHT | 11.5 | |

**NON-LATERAL SPACING**

**Table 4.2.1 showing the mass of locust bean with respect to time and temperature**

| NON-LATERAL SPACING | | | | | |
|---|---|---|---|---|---|
| | MASS OF LOCUST BEAN | | | | |
| Samples | Before drying(kg) | After drying(kg) | Mass of Moisture content removed(kg) | Temperature($^0$C) | Time taken(mins) |
| 1 | 0.55 | 0.52 | 0.03 | 90 | 82 |
| 2 | 0.55 | 0.51 | 0.04 | 93 | 79 |
| 3 | 0.55 | 0.5 | 0.05 | 95 | 77 |
| 4 | 0.55 | 0.49 | 0.06 | 98 | 75 |
| 5 | 0.55 | 0.48 | 0.07 | 102 | 73 |

Figure 4.2.1 showing the graphical illustration of mass of locust bean before and after drying with the mass of moisture content removed

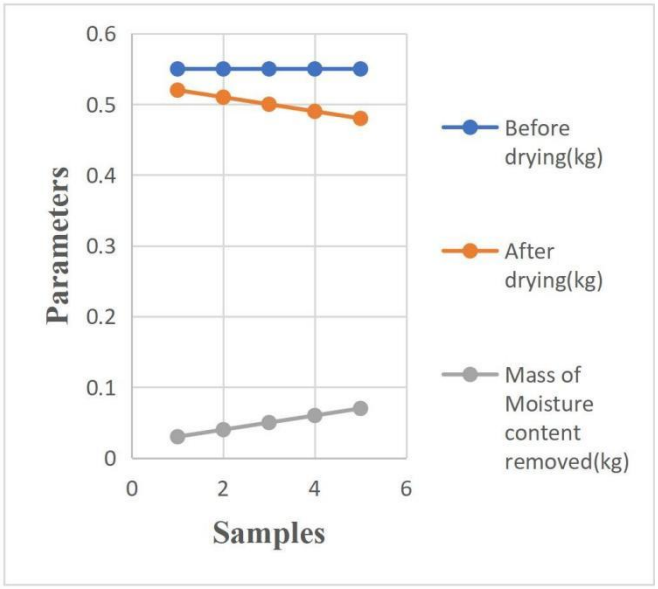


Figure 4.2.1: Graphical illustration of mass of locust bean before and after drying with the mass of moisture content removed

**Discussion:** The mass of locust beans using non-lateral spacing method was plotted on the graph comparing the mass before drying and after drying and it was found out that as mass of locust bean after drying get reduced after each samples the mass of moisture content removed keep increasing with equal mass of locust bean before drying due to the fact that the locust bean dryer has already been pre-heated.

Figure 4.2.2 showing the graphical illustration between time taken to dried the locust bean and number of sample taken

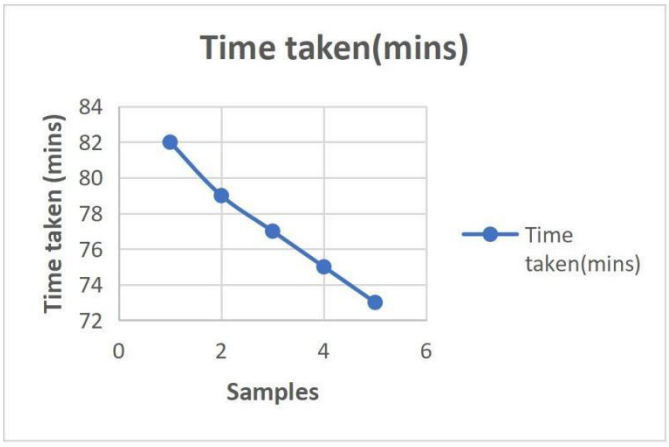


Figure 4.2.2: Graphical illustration between time taken to dry the locust beans and number of sample taken

**Discussion:** We can deduced from this graph that with subsequent loading of the same mass of locust bean, the time taken to dried the wet locust bean keep reducing. This is due to the increase in preheating the drying chamber of the locust bean dryer and gradual increase in temperature.

Figure 4.2.3 showing the graphical illustration between temperature and time taken to the number of samples taken to obtain an optimum dryness of the locust bean.

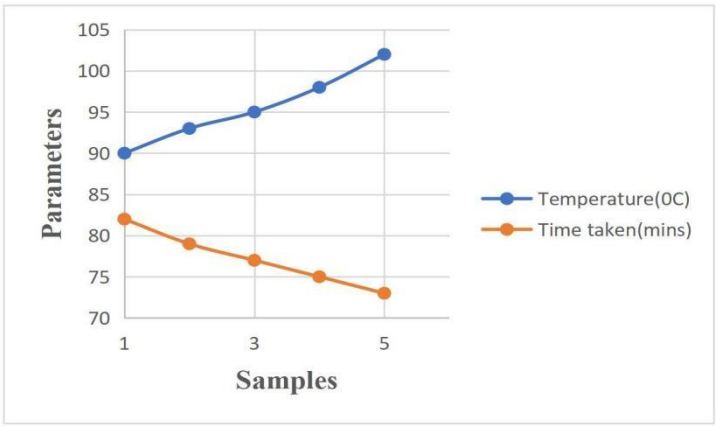


Figure 4.2.3: Graphical illustration between temperature and time taken to the number of samples taken to obtain an optimum dryness of the locust bean.

**Discussion:**

Sample 1

At $90^0$C the time taken is 82mins

Sample 5

At $102^0$C the time taken is 73mins

We can deduced from this graph that as the temperatureget increased after been pre-heated, the time taken get reduced.

Figure 4.2.4 showing the graphical illustration between the temperature and time taken in drying the locust bean

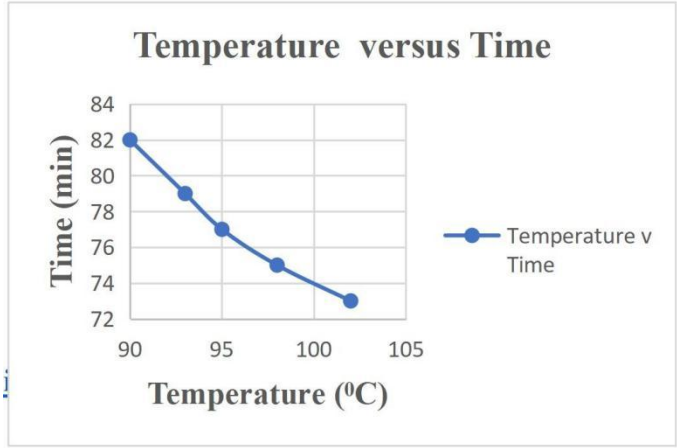

Figure 4.2.4: Graphical illustration between the temperature and time taken in drying the locust bean

**Discussion:** We can deduced that as that as the temperature of the locust bean dryer get increased, the time taken to dried the locust bean keep reducing because more heat is made available in the locust bean dryer.

**Table 4.2.2 showing mass of charcoal before and after drying and mass of charcoal used**

| NON-LATERAL SPACING | | | |
|---|---|---|---|
| | MASS OF CHARCOAL | | |
| Samples | Before drying(kg) | After drying(kg) | Mass of charcoal used(kg) |
| 1 | 3.0 | 0.5 | 2.5 |
| 2 | 3.0 | 0.6 | 2.4 |
| 3 | 3.0 | 0.9 | 2.1 |
| 4 | 3.0 | 1.0 | 2.0 |
| 5 | 3.0 | 1.3 | 1.7 |

Figure 4.2.5 showing the graphical illustration of the mass of charcoal after drying to the mass of the charcoal used.

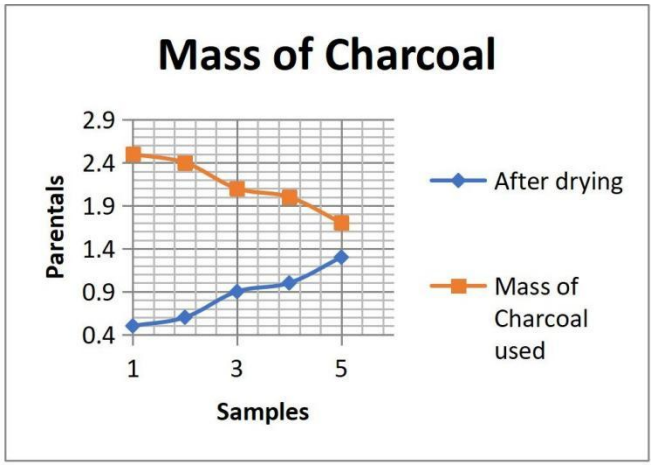


Figure 4.2.5: Graphical illustration of the mass of charcoal after drying to the mass of the charcoal used.

**Discussion:** The higher the temperature the higher the mass of charcoal burnt and the lower the mass of charcoal residue left. We found out that with equal mass of Charcoal before drying, the total mass of charcoal after increases and the residue left in the coal pot reduces

### 4.3 LATERAL SPACING

**Table 4.3.1 showing the mass of locust bean with respect to time and temperature**

| LATERAL SPACING | | | | | |
|---|---|---|---|---|---|
| | MASS OF LOCUST BEAN | | | | |
| Samples | Before drying(kg) | After drying(kg) | Mass of Moisture content removed(kg) | Temperature($^0$C) | Time taken(mins) |
| 1 | 0.55 | 0.37 | 0.18 | 89 | 75 |
| 2 | 0.55 | 0.38 | 0.17 | 92 | 70 |
| 3 | 0.55 | 0.4 | 0.15 | 95 | 68 |
| 4 | 0.55 | 0.4 | 0.15 | 105 | 65 |
| 5 | 0.55 | 0.45 | 0.1 | 110 | 60 |

Figure 4.3.1 showing the graphical illustration of mass of locust bean before and after drying with the mass of moisture content removed

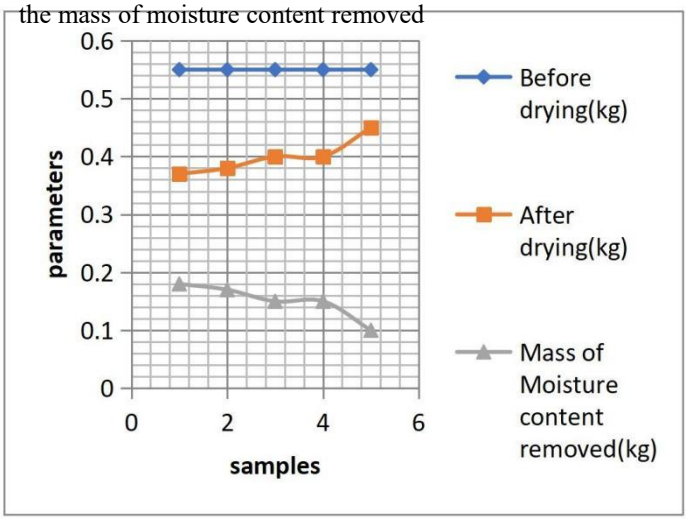


Figure 4.3.1: Graphical illustration of mass of locust bean before and after drying with the mass of moisture content removed

**Discussion:** With equal mass of locust bean before drying, we found out that mass of locust bean after drying reduced more compared to non-lateral and larger mass of moisture content was removed. This occurs due to the advantage of the space left between the tray and the body. It proves that lateral spacing method is more faster in drying locust bean

Figure 4.3.2 showing the graphical illustration between time taken to dried the locust bean and number of sample taken

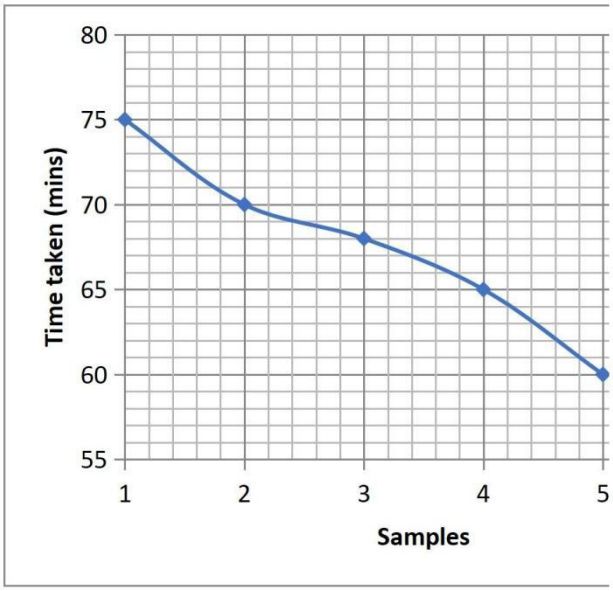


Figure 4.3.2: Graphical illustration between time taken to dried the locust bean and number of sample taken

**Discussion:** We can deduced that the time taken for the locust bean to be dried was lesser to that of non-lateral spacing and as more sample was loaded so the time taken get reduced

Figure 4.3.3 showing the graphical illustration between temperature and time taken to the number of samples taken to obtain an optimum dryness of the locust bean.

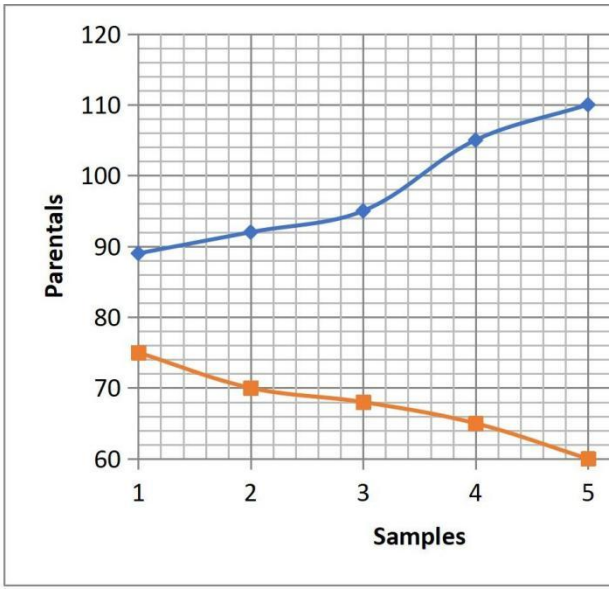


Figure 4.3.3: Graphical illustration between temperature and time taken to the number of samples taken to obtain an optimum dryness of the locust bean.

**Discussion:** We can deduced from this graph that as the temperature increased at equal mass of locust bean before drying so the time taken get reduced due to the pre-heating of the locust bean dryer.

Figure 4.3.4 showing the graphical illustration between the temperature and time taken in drying the locust bean

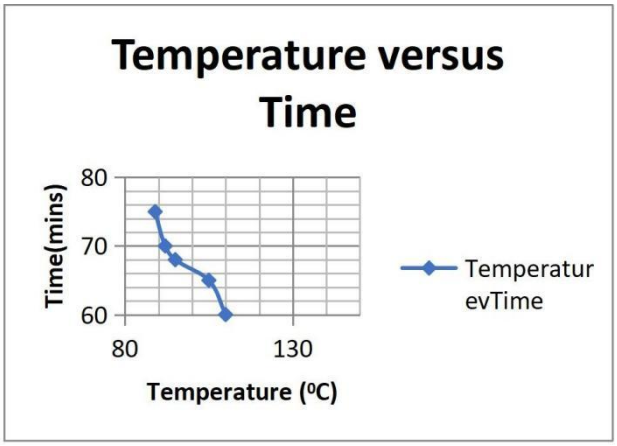


Figure 4.3.4: Graphical illustration between the temperature and time taken in drying the locust bean.

**Discussion:** We can deduced from this graph that the higher the temperature the lower time taken for the moisture content to be removed

**Table 4.3.2 showing mass of charcoal used with the same mass of charcoal before drying**

| LATERAL SPACING | | | |
|---|---|---|---|
| | MASS OF CHARCOAL | | |
| Samples | Before drying(kg) | After drying(kg) | Mass of charcoal residue(kg) |
| 1 | 3 | 0.8 | 2.2 |
| 2 | 3 | 1 | 2 |
| 3 | 3 | 1.3 | 1.7 |
| 4 | 3 | 1.6 | 1.4 |
| 5 | 3 | 1.9 | 1.1 |

Figure 4.3.5 showing the graphical illustration of the mass of charcoal after drying to the mass of the charcoal used.

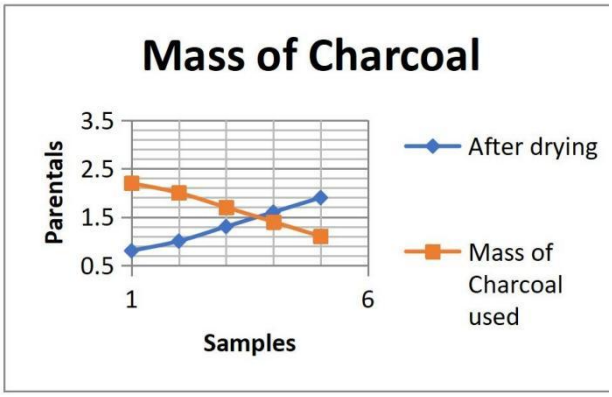


Figure 4.3.5: Graphical illustration of the mass of charcoal after drying to the mass of the charcoal used.

**Discussion:** For the advantage of the space the mass of charcoal burnt was minimal compared to non-lateral spacing. As the mass of charcoal after drying get increased the residue get reduced. We found out that the mass of charcoal burnt after drying of the locust bean was minimal.

### 4.4 Discussion

It was observed that as the locust bean was drying, a certain temperature was attained were further drying will bring about burning of the locust bean. The target of the project is to ensure preservation of locust bean for a longer period of time, still retain the taste. So therefore the heat generated was reduced and the temperature was maintained within $95^0$C and I found out that it takes lesser time for the lateral spacing to achieve optimum dryness than the non-lateral spacing. Comparing both methods, In Lateral spacing, quantity of charcoal used was lesser and also it is faster compared to non-lateral spacing. After comparing the result and the graphical illustration of the result, we found out that Lateral Spacing is more economical than Non-lateral spacing and it is more faster in the removal of moisture content within the shortest period of time. With this result, I hereby recommend that lateral spacing locust bean dryer is more effective method in drying locust bean.

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