JEES JOURNAL OF ENGINEERING AND EARTH SCIENCES

JEES ISSN: 1897-8680

JEES 2021

VOLUME 14 ISSUE NO 1

PAGE 20-28

PROLONGING THE SHELF LIFE OF RIPE PLANTAIN WITH DIFFERENTIAL AIR ASSISTED DRYING

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ABSTRACT

This paper presents the outcome of the experiment conducted to investigate how to prolong the storage life of ripe plantain. Literatures reviewed showed that ripe plantain rarely retains its freshness beyond 15 days. Mature plantain was obtained and left under room condition to commence ripening process. The mass of sizable plantain fingers ranged between 240 g to 270 g. The average moisture content of ripe plantain was 62.7 per cent. Drying of sliced and mashed ripe plantains took place in air-assisted electric oven at 80^{o}C for 12 hours (first stage) and at 65 ^{o}C for another 48 hours (second stage). Oily juice, a sign of gelatinisation, was found on the surface of the material after 30 hours of drying. The model of drying was Y = 10.38x + 219.66 with a moderate fitted data R mean square of 0.6271. Sliced ripe plantain showed rapid response to the first stage of drying than the mashed sample. The two samples had close gentle rate of drying at the second drying stage. Both dried samples stored for over 150 days and were very stable in their physical qualities. Whereas, the undried sample went completely bad before 30 days. The dried sample did not readily reverse to its original fresh fruit condition but it could still be used as food additive or garnish with little pulverization.

KEYWORDS: Food security; Gelatinisation; Postharvest waste; Ripe plantain; Safe moisture content; Sucrose content

INTRODUCTION

The population of Nigeria, according to World Bank (2017), Adeyemo (2018), Countrymeter (2018) and Nigeriafinder (2018) stood at 194.6 million with annual growth rate of 2.67 percent. Nigeria is among major crude oil exporting nations in the world accounting for 37.45 billion barrels which represents 3.1 percent of world's crude oil reserve. Despite the abundant presence of natural resources, the people of Nigeria are largely poor. The rate of youth unemployment is estimated at about 50 million. In early January of 2018, it was reported that, 40.9 per cent of the population was aged below 15 while the 15-65 years' bracket constituted 55.9 per cent and persons aged from 65 and above accounted for 3.1 per cent. In absolute figures, 77,599,973 of young Nigerians are under 15 years old. An average of 13 per cent of this figure was at risk malnutrition.

According to IFAD (2017) and Odimegwu (2018), agriculture was the mainstay of Nigeria's economy. Up to two-third of the country's population was engaged either directly or indirectly in agriculture. Despite the fact that Nigeria accounts for world's largest production of cassava, yam, and cowpea; much of food supply to her population depend on importation (IFAD, 2017). Food importation had been adversely affecting the foreign reserve of the nation therefore causing trade deficit to Nigeria at the international market (All Africa, 2018). It was estimated that about 70 million Ha of Nigerian land could support agricultural practice, but less than 35 million

Ha was being used for that purpose. The level of farming technology remained very low as the peasant farmers still depend on primitive implement to till their small plots while their output remains largely subsistence. The heavily fragmented plots owing to land tenure system was vulnerable to deforestation, and overgrazing, aridity, erosion and flooding depending on the geographical location. The frustration encountered by the agricultural sector was not unconnected with the mismanagement of oil resource by leadership of Nigeria. Recently, the economy was heavily reliant on oil while the former main stay (agriculture) was almost totally neglected.

A major challenge facing Nigerian agriculture was post-harvest waste. 30% to 40% of the many foods produced in Nigeria were ultimately wasted. Nigeria's food waste had hit $750 billion yearly. This waste caused hunger among the people of Nigeria. Nigeria had the highest number of stunted children under the age of five in sub-Saharan Africa and second highest in the world with 37 per cent of all children stunted, 18 per cent wasting and 29 per cent underweight (Odimegwu, 2018).

Matemilola and Elegbede (2017) highlighted some challenges facing food security in Nigeria which include, insufficient production, gender inequality, inefficient policies and corruption, conflicts and civil insecurity, climate change, natural disaster and low technology for processing and storage. Statistical information claimed that agricultural sector made substantive contribution to non-oil growth in Nigeria. It was therefore necessary to find urgent solutions to the challenges facing the sector.

Apart from Nigerian Government's several initiatives to revamp agriculture, foreign interventions were also exerting strong force to support the noble agenda. For example, USAID (2018) claimed it targeted to focus on rice, aquaculture, maize, cowpea and soy production. At the same time aiming at linking farmers to specialized markets, which could increase overall competitiveness, increase access to finance, promote farming family incomes. The organization aimed to help 3.6 million farmers gain access to new tools or technologies, build the skills and ability of policy analysts to advocate for improved trade and transportation infrastructure. It also aimed to promote laws and regulations to improve dissemination of agricultural technologies by the private sector and employment in the agricultural sectors. These activities were believed to reduce poverty by increasing incomes, improving nutrition, and building household resilience to external shocks.

Plantain was among the many domestic crops that can assist to ameliorate hunger and starvation in Nigeria. Plantain was widely grown in the humid tropical wetlands of Southern Nigeria up to the fringe of Niger-Benue confluence. It was a popular item in the menu of the people of Nigeria. Plantain was eaten either as unripe or ripe form. The fruit begins to ripen between 10 to 20 days after harvesting depending on the level of maturity.

According to Mohammed (2018) and Graphics Online (2018), ripe plantain contains all the necessary vitamins, minerals and some calorific values except vitamin A and C. But the green one was said to have vitamin C and the essential minerals. Plantain contains 36 per cent of human daily recommended amount of vitamin A intake. Plantain is a powerful antioxidant. It helps control human body immunity against many diseases. It promotes healthy brain function. It contains vitamin B6 (pyridoxine), which generates several important neurotransmitters that carry information from one cell to another (Reiter, 2019; Graphic Online, 2019).

Plantain is a good source of magnesium which assists in regulating blood pressure (Clifford, 2019). In West Africa, plantain fruit could be eaten cooked, roasted, fried or baked. A better way to eat plantain is when it is ripe. Dinho (2018) and Albert, (2018) reported many recipes to which plantain and banana could be

turned which include baked plantains with coconut, baked plantains with bacon and cheese, battered stuffed ripe plantains, plantains with brown sugar syrup, ripe plantain guava and cheese balls and others.

Ripening in plantain occur naturally either on the tree or on the ground after harvesting. Plantain ripening process in the commercial environment is often assisted (Gusto, 2018). Unlike many other fruits including banana, ripe plantain continues to retain its firmness, shape as ripening progresses. Ripening is noticed as the back sheet covering turns from its green colour to yellow, brownish and black. All through those stages, the inner flesh remains creamy in colour but increasingly changes to sweet creamy flesh with banana flavour (Albert, 2018). Ripe plantain is usually eaten raw, boiled, fried mostly as garnish for rice and beans (Arrivillaga, 2018). Zora (2018) recommended that it is better to boil ripe plantain to prolong its shelf life. This same author recommended that prolonging plantain could be achieved if peeled, blended and frozen.

To salvage the food resource left in plantain when ripe and even as its going bad, the indigenous people in Southwestern Nigeria innovated some ways to put over ripe plantains to economic use. These include 'Dodo Ikire' (Guardian, 2018), over ripe plantain cake (Njafoodie, 2018) and corn pudding (Anonymous, 2018).

Ripening process eventually leads plantain to deterioration. This condition remained a major concern to farmers and food security programme. Several attempts have been made to ameliorate this problem in the past. Akomolafe and Aborisade (2017) observed plantain fruit ripening in different containers like wooden bow, earthen pot, desiccators, and sawdust covering. They discovered that fruits stored in wooden cabinets attained full yellow colour on 15 day, those in pots on 17 day and those in desiccators remained green throughout the storage period of 21 days. Oyewole (2012) arrived at the conclusion that the shelve life of plantain fruits was 13 days in pots and wooden cabinets while it was more than 24 days in desiccators. This work did not categorically explain what happened to the plantain after ripening. They only pointed out that ripening was an indication of spoilage.

Umeh et al., (2017) and Fajinmi et al., (2011) also studied the effects of microorganisms and storage of plantain in Nigeria. Both groups submitted that plantain takes 24-28 days to ripen and another 14-16 days to spoil under refrigeration. Other treatments took lesser days to ripen and spoil. The longest time to achieve this which was confirmed by Hughes (2018) was recorded for plantain stored under low temperature i.e. refrigeration system.

Akomolafe and Aborisade (2007; 2017) and Arrivillaga (2018) observed the behaviour of green plantain fruit treated with conidial suspension of Fusarium verticillioides under hot air at 38 and 44°C for 5 min, 53°C for 3 min, hot water at 50°C with 5 ppm Benlate (Benomyl) and 5 ppm Benlate only. They discovered that disease control on the fruit was significantly more effective under these treatments as against those without chemical treatment.

Among the previous research work on plantain, it was clearly established that ripe plantain is in mostly preferred by consumers. It was also shown that there was appreciable production of plantain in Nigeria. The supply of ripe plantain was restricted within a very short period of the year thereby creating glut at the peak supply and scarcity during the off-season period. To correct this anomaly in the supply chain, there is need for spreading part of the surplus supply in the peak production period to supplement the supply stock in the scarcity period. This could be

achieved using efficient processing and storage methods which does not depend much on electricity power supply and very complicated technology. Ripe plantain is a product of deterioration which is close to the tail end of perishing. But information on how to prolong ripe plantain for appreciable long time was not readily available. This is one of the reasons why this research became necessary.

MATERIALS AND METHOD

The materials used for this work include 5 bunches of mature plantain fruit (Green), chopping board, knife, blender, electric oven, spread tray, vegetable oil and laboratory space. The research was carried out in the Post-harvest laboratory of the Department of Agricultural and Bio-Environmental Engineering in the Federal Polytechnic Ado Ekiti Nigeria. In the plantain peak supply season of June-September 2017 and 2018.

During the experiment, very good fingers of mature plantain were selected from the five bunches and mixed together to eliminate individual quality bias. In all, 30 fingers were used for the experiment. The plantain samples were left undisturbed in clean environment devoid of pests, excessive moisture, and heat. The plantain samples were inspected daily to know when the green coloured skin begins to turn to yellow. Thereafter, the ripe plantains were held within the palm and gentle pressed to test their readiness for consumption.

Two fingers of plantain were processed at a time. A sample was sliced along the transversely into thin thickness of between 3-5 mm. The sliced plantain samples were gently laid on a metal welded mesh trays provided in the oven. The materials were dried for 28 hours at 80^{o}C for proper gelatinisation and prevent decay. Thereafter, drying was continued for another 48 hours at 65^{o}C to a safe moisture content of 12per cent dry basis in air assisted drying oven.

Another finger sample were peeled and blended to pulp. The pulp was spread in the spread metal box coated with a thin layer of vegetable oil (to reduce stickiness to the place) to attain a thickness of 3-5 mm. The tray containing the pulp was placed in the oven and dried subjected to the same heat treatment given to the sliced samples.

The third sample was left in the store to continue the process of ripening and eventual spoilage. The three samples were left in the store and their physical properties, (texture (softening), taste, odour and moisture development) were observed.

RESULTS AND DISCUSSION

Average weight of plantain finger ranged between 240 and 270 g as shown by the trend line of the graph in Figure 1. The trend was biased toward the very healthy sizable plantain common in the farm produce market. The average would have been wider for production during off season or when soil moisture is inadequate in supply. The value of R^2 of 0.2161 indicated that there was a wide range of plantain weight hence the low fitting value. Even on the same bunch, the weight of plantain fingers varied widely. If other hybrids of plantain were considered in the statistical analysis, there is likelihood that the R^2 value will reduce more than the one obtained in the experiment. The implication of this is that processing/handling system for plantain finders will have wide adjustable clearance. And that may affect the simplicity of design, the cost of fabrication and operation.

The moisture content of ripe plantain varies proportionally to the degree of ripeness. The more the plantain ripens the higher the moisture content. This is because much of the carbohydrate content would have converted to simple sugar and water. This also explains the loss of firmness of the

ripe plantain as it becomes ripened further. The average moisture content of fresh ripe plantain obtained using gravimetry method was 62.7 per cent. The material used was dried from a weight of 285 g over 48 hours until the rate of weight loss reduced to near zero (Figure 2). The equation of the graph (Y= -10.38x + 219.66) defined the model of drying of ripe plantain. The R^2 value of 0.6271 reveals that the values of rate of drying were close meaning that during drying process the rate of drying was even. It equally tallied with the computed value of moisture content (Dry Basis). This was asserted by the gentle slope of the graph particularly after 8 hours of drying. This was necessary for the formation of gelatine in the end product and was equally good for natural preservation of the product.

Figure 3 shows the graph of the behaviour of sliced sample of ripe plantain under oven drying process. The material rapidly loss much moisture in the first segment of the process which was about the first 8 hours. The rate of weight loss which was defined by the model of the graph (Y = -13.388x + 138.71) drastically reduced from 285 g to about 10 g. Gelatine formation was noticed after about 6 hours of drying. The samples stared showing drying consistency after about 8 hours of drying. Thereafter, the rate of drying became even as show in the graph section after 4(x3) hrs Further formation continues until the rate of moisture loss became constant. Thereafter, the rate of weight loss became very low until no appreciable moisture was lost even with further drying. However, the ripe plantain slice did not become brittle. It was elastic and tough. It did not crumble like the unripe plantain. It tasted like the fried ripe plantain. This may be a way of reducing ripe plantain processing because the cost of vegetable oil used for frying ripe plantain may sometimes be uneconomical particularly for those who are engaged in processing of ripe plantain for commercial purpose. However, it was difficult to hydrolyse, hence reversing the drying process was difficult.

The drying process for sliced ripe plantain was repeated for blended ripe plantain. The pulp was spread in a tray at an average thickness range of 3 to 5 mm. The rate of drying was as presented in Figure 4 below. The drying rate was very slow at the initial stage. Turning was difficult because of the pulpy condition of the mash. However, gelatine formation started earlier in the blended plantain than in the sliced one. The pulp became set after 9 hours of drying. Thereafter, rate of drying became reduced drastically after 18 hours of drying. There was steady uniform weight loss after 18 hours of drying. The computed average moisture content was 61.5 percent which again was close to the R^2 of the graph in Figure 4.

Comparison between the responses of sliced and pulped ripe plantain to drying treatment is graphically presented in Figure 5 below. Before the drying length of 21 hours was reached, pulped ripe plantain showed a slow response. This means that it took longer time for the pulped plantain to dry. Whereas. The rate of drying in the sliced plantain was faster (graph in blue. But after the 21 hours of drying, the drying rate became almost similar in both cases.

Storage: Both dried sliced and pulped ripe plantain retained their state of quality for five months without any decomposition. However, some caterpillars were found on the covered pulped plantain while the ones that were left in the open still remained intact. The skin of untreated ripe plantain turned from yellow colour to dark brown with black patches, later to complete black. This process took just 18 days. At this stage, the inner flesh still remained edible. But at 30 days in the store, the inner flesh had deteriorated and became watery and even developed foul smell. In summary, while the dried ripe plantain lasted for more

than 6 months, the untreated samples did not last for more than 28 days.

Although, the experiment was able to prolong the shelf life of ripe plantain for as long as 6 months, the end product may need grinding, milling, and chopping before it could be used as garnish for rice and beans. Addition of water to the product did not readily bring it back to the raw stage of ripe plantain. However, with little addition of value, the product could serve the purpose that the unprocessed ripe plantain usually serves in the menu of those who consume it.

The first segment of the drying process needed be given careful attention. This section was the part when moisture content of ripe plantain had to be removed rapidly from the material. This operation is necessary to reduce microbial attach on the material. In the local environment, this rapid drying at this crucial stage may be difficult to achieve, hence compromising the quality of the end product.

CONCLUSIONS

In conclusion, ripe plantain was subjected to air assisted drying in order to extend its stability after harvesting. The drying process adopted promoted gelatine formation in the material which enhances stabilization and reduced microorganism actions on the material. It was observed that the dried materials could stay on the shelve for over 6 months while that one that did not pass through drying process did not last for more than 28 days. It is recommended that for a community to continue to have ripe plantain in supply after the peak period, it should be subjected to air assisted drying. Drying in the open air may not give the desirable result because the sugary and honey aroma of plantain will attract insect and dangerous germs to it.

RECOMMENDATIONS

Since it was established that drying could prolong the shelve life of ripe plantain, drying facilities should be provided to the farmers to handle their plantain particularly during the rainy season so that post-harvest loss annually experienced by farmers could be reduced. Alternatively, the government and organized private sector should create mop-up programme for plantain to buy this produce off the farmers and arrange to dry it in a centralized processing centres.

At the consumption end, the orientation of eating plantain with a particular mindset or form which we have lived with for years should be unbundled. A pool of ripe plantain slakes should emerge along the food chain from where end usage of dried ripe plantain can source input. Food processing industry should evolve mechanisms of using dried ripe plantain as whole or partial additive to finished food item. This arrangement can assist the food security programme of the government and the United Nations.

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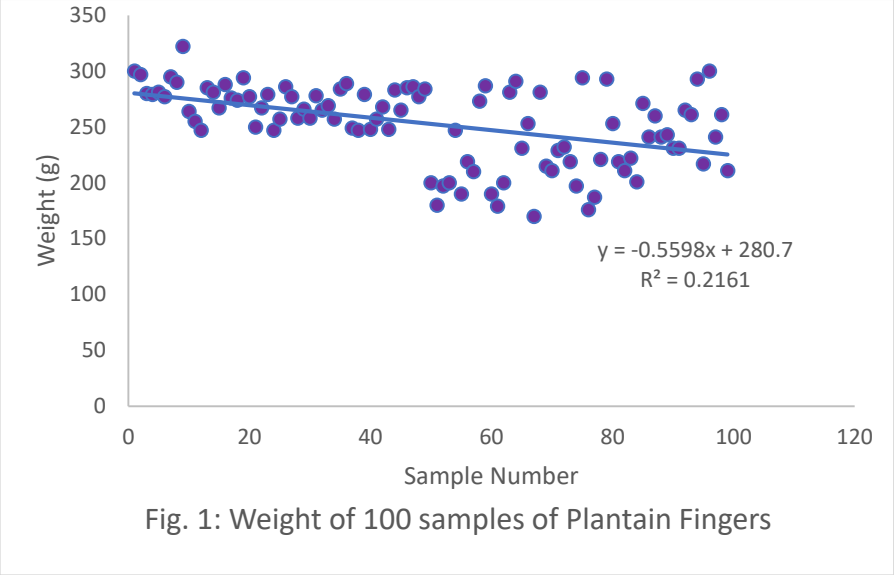

Figure 1: Weight of 100 samples of plantain fingers

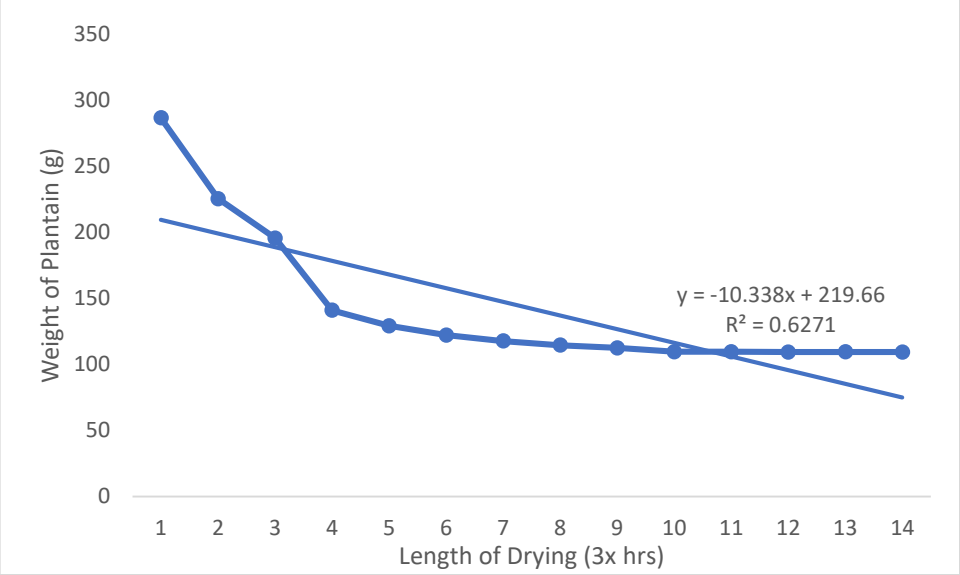

Figure 2: Ripe plantain moisture content determination using gravimetric method

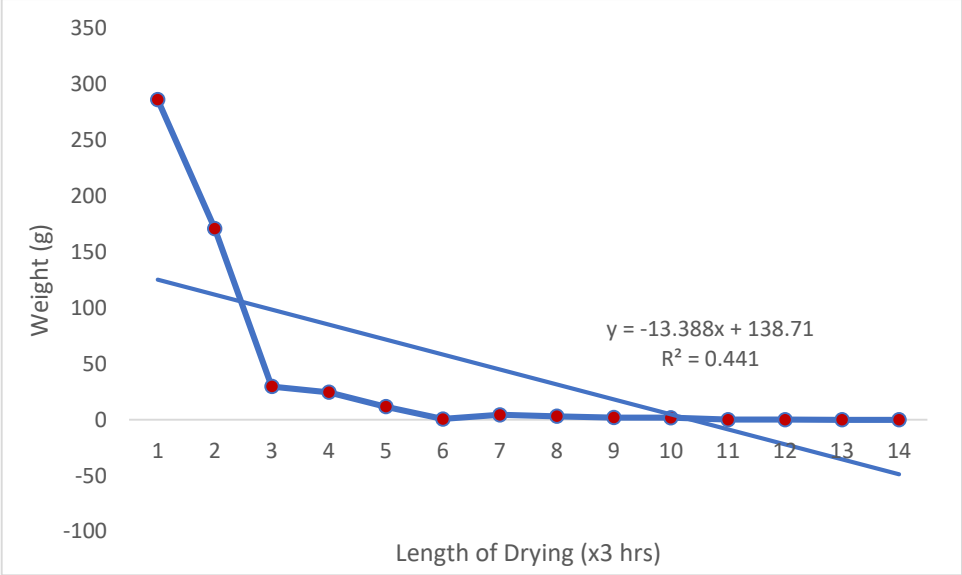

Figure 3: Rate of drying of sliced ripe plantain

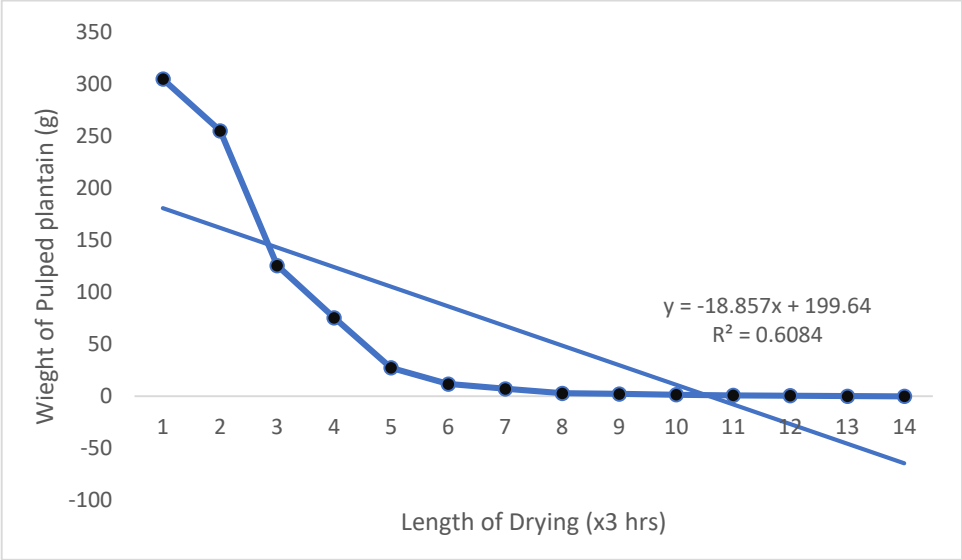

Figure 4: Rate of drying of ripe plantain (Pulped)

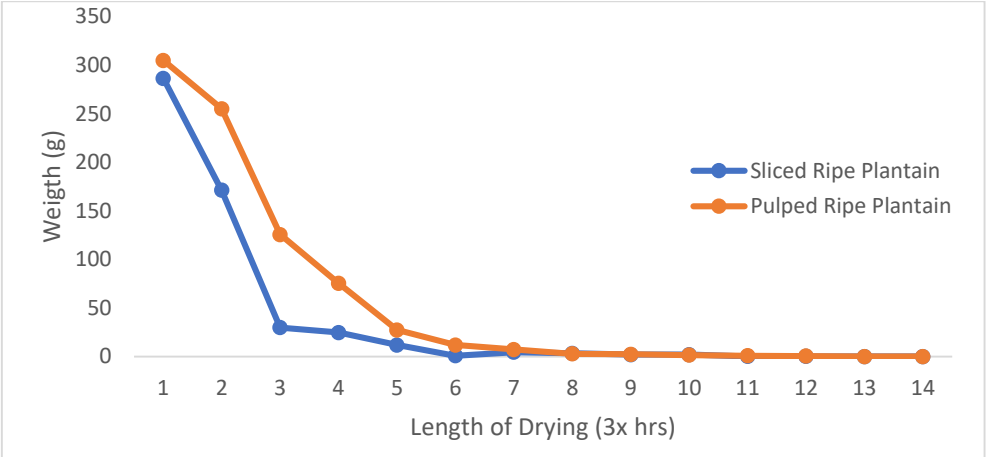

Figure 5: Comparison of drying rate in both sliced and pulped ripe plantain