ICRRD Journal
INTERNATIONAL CENTER FOR RESEARCH AND RESOURCES DEVELOPMENT article
ISSN Number: 2773-5958, SSM Number: (1347468-T), doi.org/10.53272/icrrd, www.icrrd.com

Quantitative Effects of Drying on Ripe and Unripe Plantain Using Convective Dryer

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Received: 10 July 2022
Revision: 20 August 2022
Accepted: 12 February 2023
Available Online: 20 March 2023
Published: 20 March 2023
Volume-4, Issue-1
Cite This: *ICRRD Journal,* 2023, 4(1), 163-173

ABSTRACT: This paper reports the effect of convective heat on plantain (*Musa paradisiaca*). Ripe and unripe plantains were bought from Eremi-adale local market in Ado-Ekiti, Nigeria. The samples were washed, peeled, sliced into mass sizes of 20g each, and load into the chamber of a fabricated convective dryer. Samples were removed from the chamber after every hour for measurement to determine their moisture losses. The plantain samples were dried at various drying time and with regulated drying temperatures of 333K, 343K, and 353K. Results of the laboratory analysis review that, the viable microbial counts decrease when the drying temperatures increase. Ripe samples were found to have higher percentage of crude fibre, fat and protein, than the unripe samples while unripe samples have higher percentage of carbohydrate and ash than the ripe samples, at the drying temperatures. It was equally reported from the proximate analysis test that, the percentage amount of moisture content, carbohydrate and crude fibre decreases when the regulated drying temperatures increase while the amount of protein, fat and ash increases with an increase of the regulated drying temperatures.

Keywords: Ripe plantain, unripe plantain, regulated drying temperature, percentage moisture content, microbial counts.

I. INTRODUCTION

Fruits and vegetables are agricultural products that have a high amount of moisture and they easily get destroyed after harvest if they are not adequately preserved. Fruit can be defined as the fleshy seed-related structures of particular edible plants that are sweet in its raw state, examples of fruits are: strawberries, apples, plantain, oranges, and grapes [1]. Nigeria is the fifth largest producer of plantain in the world, producing about 3.09 million tons per annum [2] (see Figure 1).

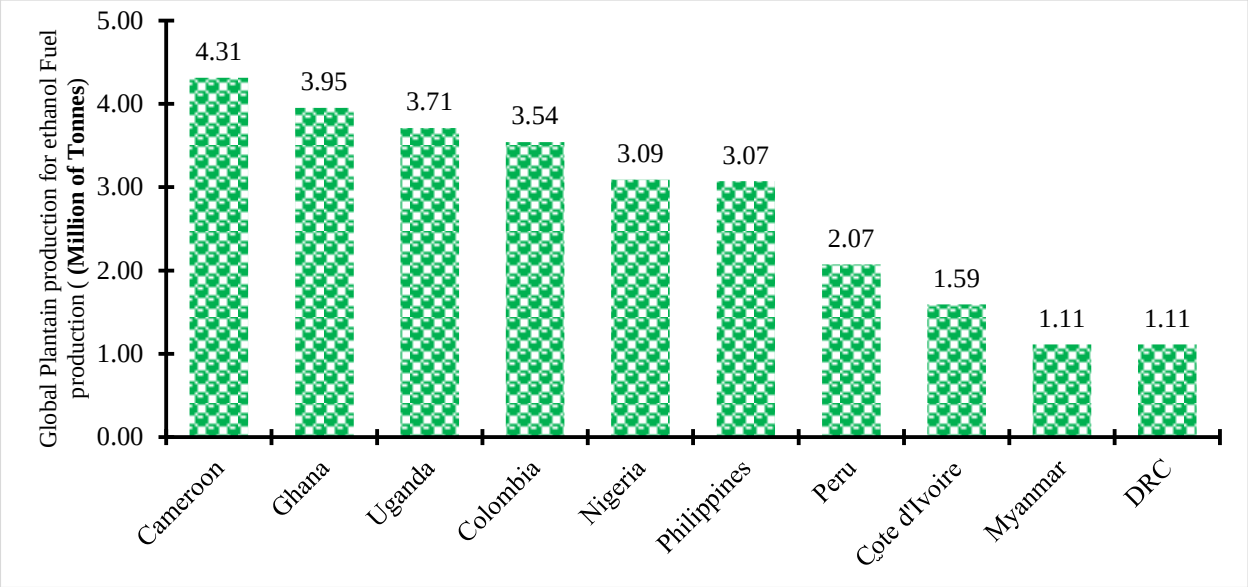


Figure 1: The World's Leading Plantain Producers [2].

Unripe samples of plantain contain certain antioxidant compound that aids the prevention of diseases, constipation and colon cancer by reducing the cholesterol and triglycerides inside the blood [3].

Fruit can be dried by cutting them into halve, sliced or even whole. Amount of residual moisture content varies from lower value range between 3% and 8% to higher value range between 16% and 18%, depending on the type of fruit [4].

Drying is control by the principle of heat transfer [5]. Drying is a process of diffusion whereby the surface moisture is transferred to the surrounding by means of evaporation, as soon as that is done, moisture is extracted from the internal part of the solid to the surface [6].

Drying is a process through which the storage life of food is enhanced [7]. It minimizes the moisture content of food products by weakening the microorganisms that causes deterioration [8]. Drying is a process of thermal where heat is supplied by hot air to the products and the water in the products is removed [8].

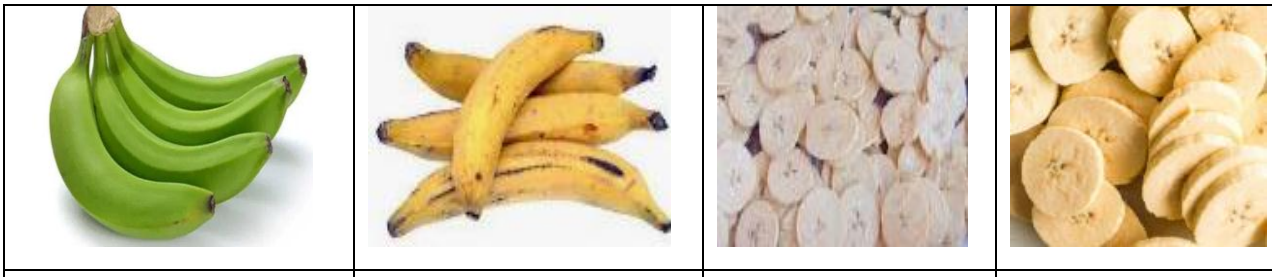
During drying, it is only the free moisture that evaporates. Free moisture is a term used to describe a phenomenon in which the moisture content of a solid exceed its equivalent equilibrium quantity and it solely depends on the concentration of the vapor [9-10]. A particular moisture content between the end point of a constant period of drying and the starting point of a falling drying period is said to be critical moisture content [11].

Promise [12] dried banana using indirect solar drying and determined its proximate analysis and microbial counts. Also, many other works on the drying of agricultural products have been published in the literature [13-19], yet, there is no adequate information on drying of plantain using regulated drying temperature. This work spotlights the drying effects using different regulated drying temperatures of 333K, 343K and 353K on plantain samples. The present work is also useful in food industries and agricultural Engineering

II. METHODOLOGY

Materials

The materials upon which the experimental investigations were carried out are ripe and unripe plantain samples. These are shown in Figure 2



(a)	(b)	(c)	(d)

Figure 2 Plantain samples: unripe (a), ripe (b), sliced unripe sample (c), and sliced ripe sample (d)

Experimental Set-up

The experimental set-up uses a convective dryer [11] which consist of the following components: drying chamber, pulley, electric motor, fan housing, thermostat, drying chamber and the cover as shown in the Figure 3. The drying chamber was constructed with a galvanized-metal sheet having a drying cage inside and a drying tray to hold the sample of plantain. A thermostat was installed on the dryer for proper regulation of the drying temperatures. The fan forces air into the drying chamber as the electric motor (1hp) drives the pulleys

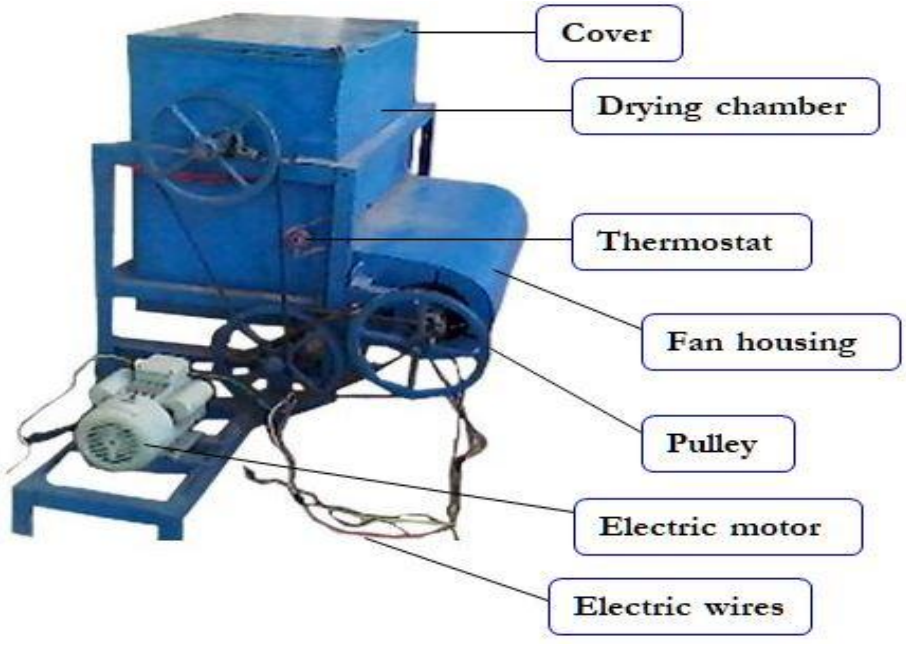


Figure 3: Pictorial view of the dryer [11]

Drying procedure

The plantain samples were collected washed, and then cut into small sizes of 20g mass measured using a digital beam balance. Plantain samples (ripe and unripe) were then loaded into the tray of the cage inside the chamber of the convective dryer. The dryer was then switched on while the thermostat was used to regulate the drying temperatures at 333K, 343K, and 353K. The plantain samples for each regulated drying temperature were allowed to dry for seven hours. Each sample was brought out of the drying chamber and weighed to determine the change in mass after 1hour. The percentage amount of water in the plantain samples was determined using the equation [1]. The microbial load analysis and proximate analysis of the plantain were carried out.

Basic Theoretical Equation

Percentage moisture content as drying progresses is estimated using a wet-basis and expressed by equation [1], adapted from [20]

$$M_C = \frac{\mathrm{m_{ap}} - \mathrm{m_{Ap}}}{\mathrm{m}_b} \times 100\% \quad [1]$$

where;

M_C = percentage amount of water in the plantain sample at a certain time (%)

$\mathrm{m_{ap}}$ = mass of plantain sample at a certain time of drying (g)

$\mathrm{m_{Ap}}$ = mass of the plantain sample at the end of period of drying (g)

m_b = mass of the fresh plantain sample before drying (g)

III. RESULTS AND DISCUSSIONS

Results of the plantain samples dehydrated at various regulated temperatures of 333K, 343K, and 353K are presented, and the calculated percentage moisture content depicted in Figures 4 and 5.

Moisture loss

The mass of the samples at a regulated drying temperature of 333K, after dried for one hour is 16.3g and 17.2g for the ripe and unripe plantain samples respectively, as shown in Figure 4; three hours after, the mass (g) reduced to 6.3 and 8.5g for the ripe and unripe plantain samples respectively. But, when the samples were dried for six hours, the mass reduced to 3.8g and 5.3g for the ripe and unripe plantain samples respectively.

At the regulated drying temperature of 343K as shown in Figure 4, the mass of the samples at one hour is 16.1g and 17.0g for the ripe and unripe plantain samples; three hours after, the mass reduced to 6.1g and 8.3g for the ripe and unripe plantain samples respectively. When the samples were dried for six hours, the mass reduced to 3.8g and 5.3g for the ripe and unripe plantain samples respectively.

At the regulated drying temperature of 353K, as shown in Figure 4, the mass of the samples at one hour is 15.9g and 16.8g for the ripe and unripe plantain samples; three hours after, the mass reduced to 5.9g and 8.2g for the ripe and unripe plantain samples respectively. It was noted when the samples were dried for six hours, the mass reduced to 3.8g and 5.3g for the ripe and unripe plantain samples respectively, and it remains the same till drying time of seven hours. Samples were completely dried at drying time of seven hours with values of 3.7g and 5.2g for the ripe and unripe plantain samples respectively for the various regulated drying temperatures of 333K, 343K, and 353K.

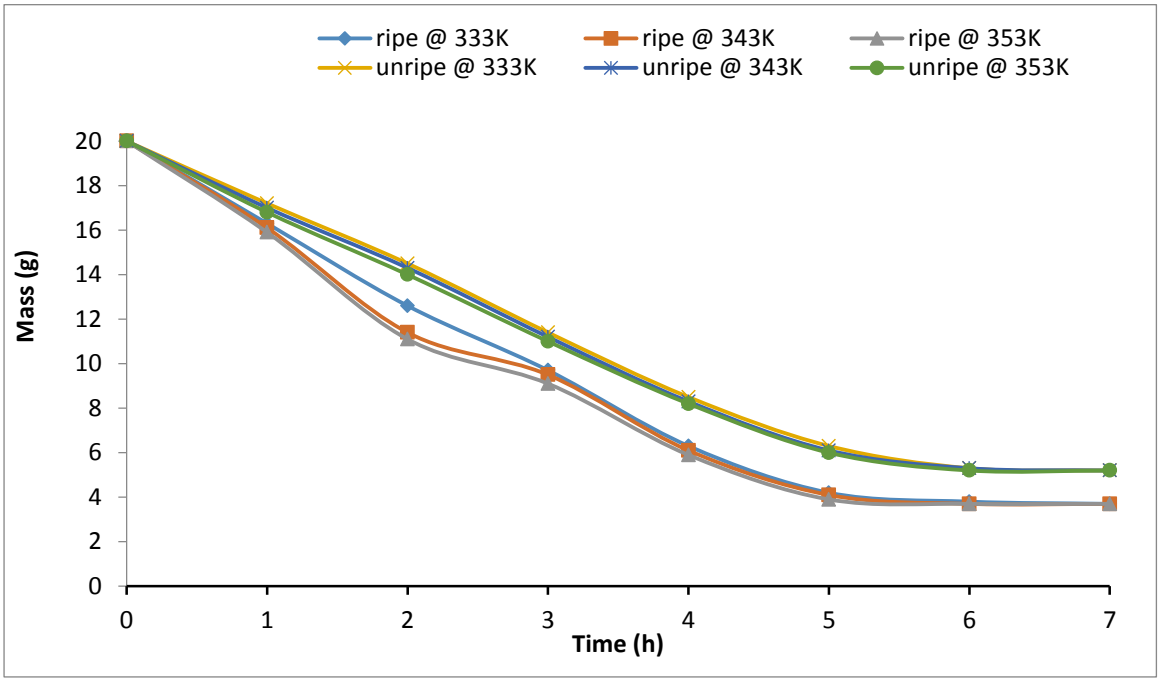


Figure 4 Mass (g) of the plantain sample against time (h) at various regulated drying temperatures

Percentage Moisture Content

The percentage amount of moisture of the plantain samples was taken at various regulated drying temperatures of 333K, 343K, and 353K, and the results are depicted in Figure 5 below. For the regulated drying temperature of 333K as detailed in Figure 5, the percentage moisture content at drying time of 0h is 81.5% and 74.0% for the ripe and unripe plantain samples respectively, at the drying time of four hours, the percentage moisture content reduced to 13.0% and 16.5% for the ripe and unripe plantain samples respectively. But, at the drying time of six hours, percentage moisture content reduced to 0.5% and 0.5% for the ripe and unripe plantain samples, respectively.

For the regulated drying temperature of 343K (Figure 5), the percentage moisture content at drying time of 0h is 81.5% and 74.0% for the ripe and unripe plantain samples respectively, at the drying time of four hours, the percentage moisture content reduced to 12.0% and 15.5% for the ripe and unripe plantain samples, respectively. But, at the drying time of six hours, the percentage moisture content reduced to 0% and 0.5% for the ripe and unripe plantain samples, respectively.

For the regulated drying temperature of 353K as shown in Figure 5, the percentage moisture content at drying time of 0h is 81.5% and 74.0% for the ripe and unripe plantain samples, respectively, at the drying time of four hours, the percentage moisture content reduced to 11.0% and 15.0% for the ripe and unripe plantain samples, respectively.

At the drying time of six hours, the percentage moisture content reduced to 0% and 0% for the ripe and unripe plantain samples, respectively and it remains the same till drying time of seven hours. It can be simply explained that, the amount of water completely dried in the unripe samples at the drying temperatures of 333K, 343K and 353K for the drying times of seven hours, seven hours and six hours, respectively while the amount of water completely dried in the ripe samples at the drying

temperatures of 333K, 343K and 353K for the drying times of seven hours, six hours, and six hours respectively.

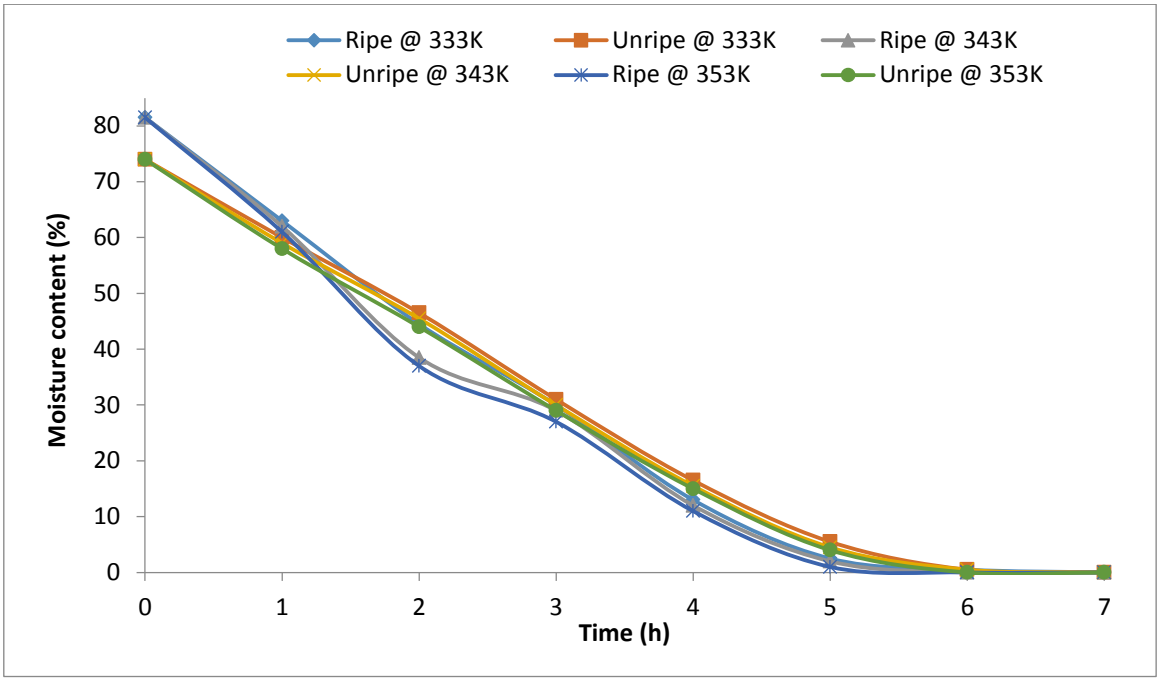


Figure 5. Percentage moisture content (%) against time (h) of the plantain samples at various regulated drying temperatures

Proximate Analysis

Proximate analyses were carried out on fresh and dried plantain samples to know the effect of the regulated temperatures on nutritional value of the plantain samples as detailed in Table 1. For the regulated drying temperature of 333K, the percentage quantity of water; ash, crude fibre, protein, fat, and carbohydrate are 81.7% and 74.7%, 0.4% and 1.1%, 1.6% and 1.5%, 1.2% and 0.6%, 0.7% and 0.1%, and 14.5% and 22.1% for fresh ripe and unripe plantain samples, respectively.

For the dried plantain samples shown in Table 1, there is increase in the nutritional contents with decrease in moisture value as detailed in Figure 4; with the drying temperature of 333K, the percentage quantity of water; ash, crude fibre, protein, fat, and carbohydrate are found to be 19.4% and 18.8%, 15.4% and 16.4%, 13.2% and 14.3%, 16.7% and 16.2%, 8.3% and 2.2%, and 27.3% and 32.1% for the dried ripe and unripe plantain samples respectively.

Also, with the drying temperature of 343K as shown in Table 1, the percentage amount of water; ash, crude fibre, protein, fat and carbohydrate are found to be 19.3% and 18.7%, 15.3% and 16.5%, 13.7% and 14.5%, 16.8% and 16.2%, 8.3% and 2.3%, and 26.7% and 31.9% for the dried ripe and unripe plantain samples respectively; with the drying temperature of 353K, the percentage quantity of water; ash, crude fibre, protein, fat, and carbohydrate are found to be 19.2% and 18.6%, 15.5% and 16.5%, 13.8% and 14.6%, 17.0% and 16.4%, 8.5% and 2.3%, and 26.1% and 31.7% for the dried ripe and unripe plantain samples respectively.

Table 1: Proximate analyses of the samples of ripe and unripe plantain

	Control		333K		343K		353K	
	unripe	ripe	unripe	ripe	unripe	ripe	unripe	Ripe
Moisture content	74.7	81.7	18.8	19.4	18.7	19.3	18.6	19.2
Ash	1.1	0.4	16.4	15.2	16.5	15.3	16.5	15.5
Crude Fibre	1.5	1.6	14.3	13.2	14.5	13.7	14.6	13.8
Protein	0.6	1.2	16.2	16.7	16.2	16.8	16.4	17.0
Fat	0.1	0.7	2.2	8.3	2.3	8.3	2.3	8.5
Carbohydrate	22.1	14.5	32.1	27.3	31.9	26.7	31.7	26.1

It was discovered from the laboratory results that the amount of moisture of the samples reduced when the regulated drying temperature increased (Figure 6). The moisture content of the ripe and unripe plantain samples was taken to be 19.4% and 18.8%; 19.3% and 18.7%; and 19.2% and 18.6%; at the regulated drying temperatures of 333K, 343K and 353K respectively. Also, carbohydrate and Crude fibre found to decrease while the drying temperatures increase but the percentage of fat, ash, and protein happens to increase as the drying temperatures increase.

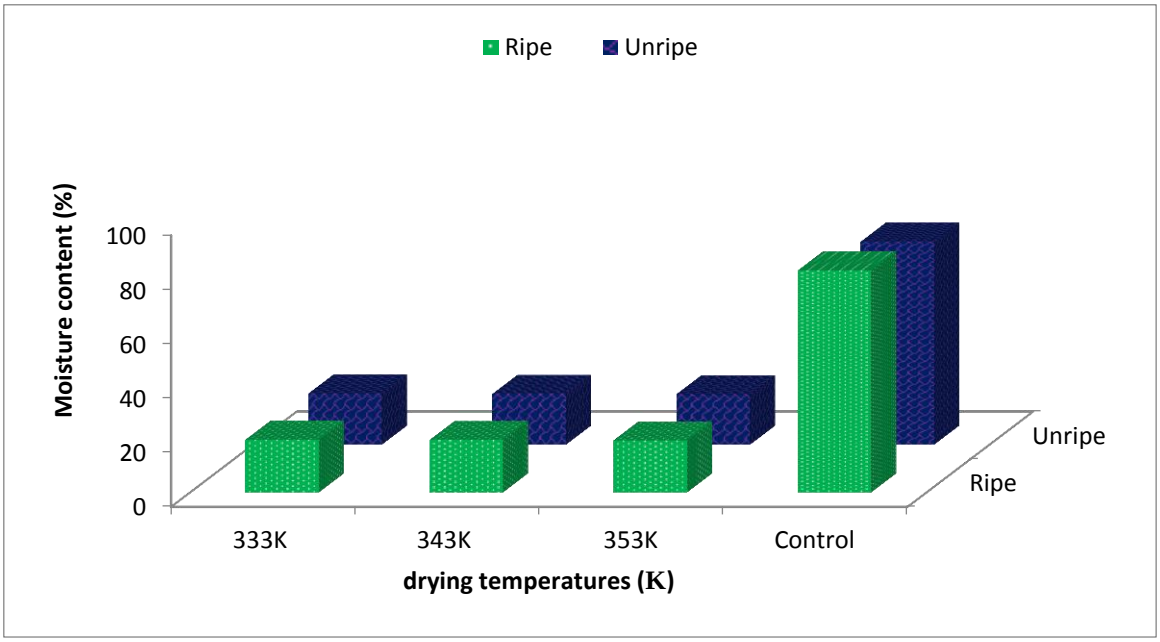


Figure 6 Amount of moisture of the proximate analysis at various regulated drying temperatures

Microbial Loads

The microbial counts of the fresh and dried plantain samples were taken to know the exact bacteria and fungi present therein and are plotted in Figure 7 to Figure 9. It could be noted here that the microbial loads decrease with the increase in drying temperature. Fresh samples (control) have

bacteria of 9.8 x 10^6 and 7.3 x 10^6 CFU/g for the ripe and unripe plantain samples, respectively. When the drying time was 3h, the bacteria counts are 6.6 x 10^6 and 4.8 x 10^6, 6.5 x 10^6 and 4.8 x 10^6, and 6.5 x 10^6 and 4.8 x 10^6 CFU/g for the ripe and unripe plantain samples at regulated drying temperatures of 333K, 343K, and 353K, respectively.

Also, at a drying time of six hours as shown in Figure 7, the bacteria counts are 4.0 x 10^6 and 3.5 x 10^6, 3.8 x 10^6 and 3.4 x 10^6, and 3.6 x 10^6 and 3.3 x 10^6 CFU/g for the ripe and unripe plantain samples at regulated drying temperatures of 333K, 343K, and 353K, respectively. Finally, at a drying time of seven hours as shown in Figure 7, the bacteria counts are 3.8 x 10^6 and 3.3 x 10^6, 3.7 x 10^6 and 3.2 x 10^6, and 3.4 x 10^6 and 3.1 x 10^6 CFU/g for the ripe and unripe plantain samples at regulated drying temperatures of 333K, 343K, and 353K, respectively.

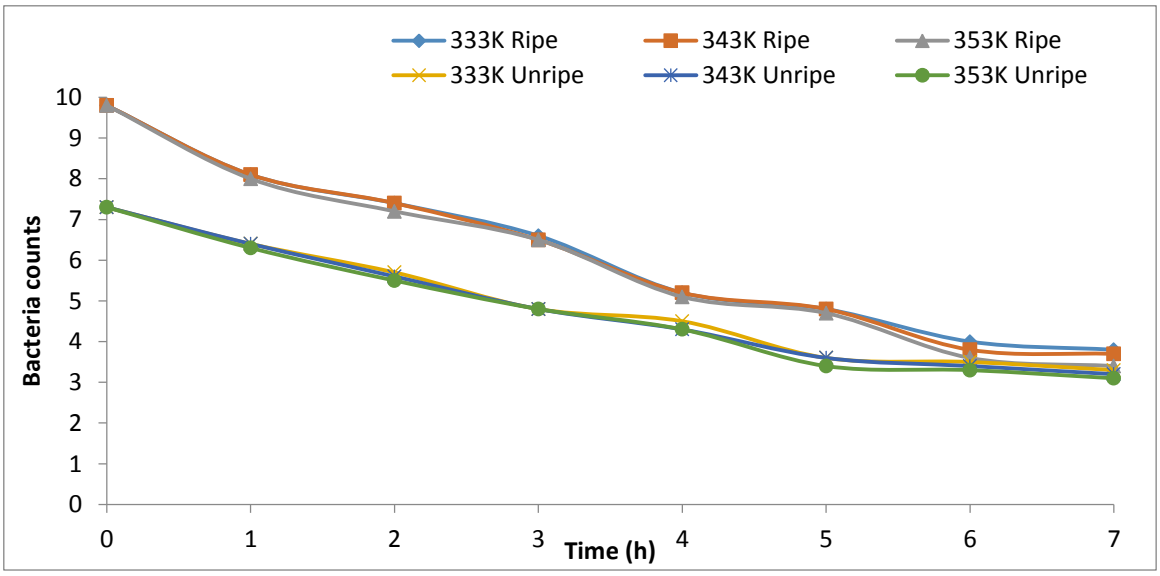


Figure 7 Bacteria counts of the plantain samples versus time (h) at various regulated drying temperature.

From Figure 8, it is revealed that the fungi counts decrease as the temperature increases. For fresh samples (control), fungi counts are 6.1 and 4.1 x 10^6 CFU/g for the ripe and unripe plantain samples, respectively. Moreover, when the drying time was three hours, the fungi counts are 4.4 x 10^6 and 3.3 x 10^6, 4.3 x 10^6 and 3.3 x 10^6, and 4.3 x 10^6 and 2.9 x 10^6 CFU/g for the ripe and unripe plantain samples at regulated drying temperatures of 333K, 343K, and 353K, respectively.

Also, at a drying time of six hours as shown in Figure 8, the fungi counts are 2.8 x 10^6 and 2.5 x 10^6, 2.6 x 10^6 and 2.5 x 10^6, and 2.5 x 10^6 and 2.3 x 10^6 CFU/g for the ripe and unripe plantain samples at regulated drying temperatures of 333K, 343K, and 353K, respectively. Finally, at a drying time of seven hours as shown in Figure 8, the fungi counts are 2.6 x 10^6 and 2.4 x 10^6, 2.5 x 10^6 and 2.4 x 10^6, and 2.4 x 10^6 and 2.1 x 10^6 CFU/g for the ripe and unripe plantain samples at regulated drying temperatures of 333K, 343K, and 353K, respectively.

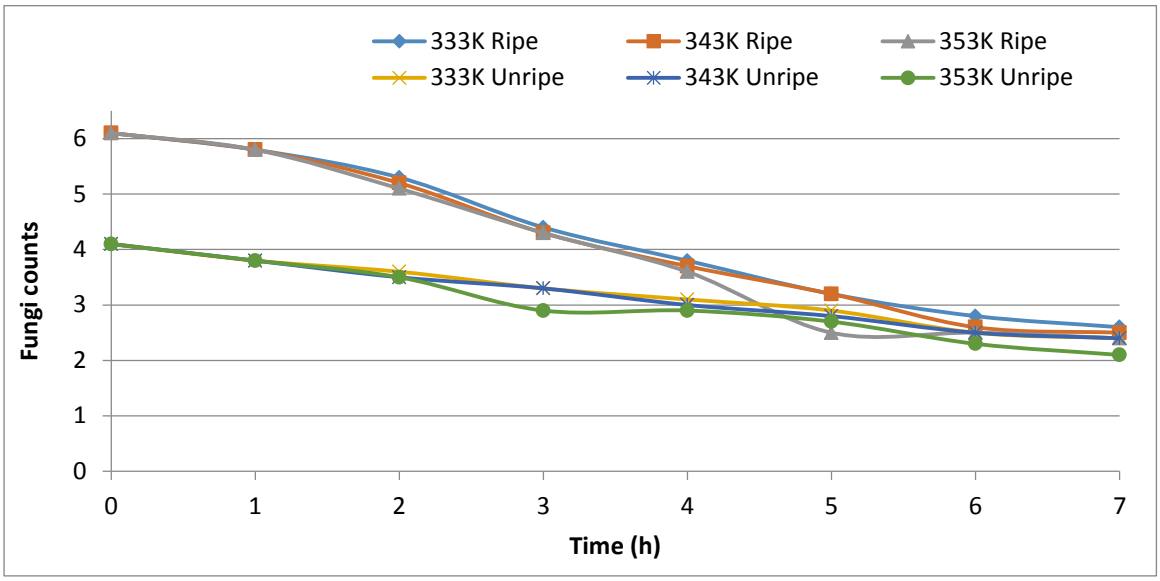


Figure 8 Fungi counts of the plantain samples against time (h) at various regulated drying temperatures.

The results of the viable microbial (bacteria and fungi) counts (Figure 9) have reviewed that drying temperatures significantly affect the microbial counts. It can be established here that, microbial counts decrease as the temperature increases (Figure 7 and Figure 8).

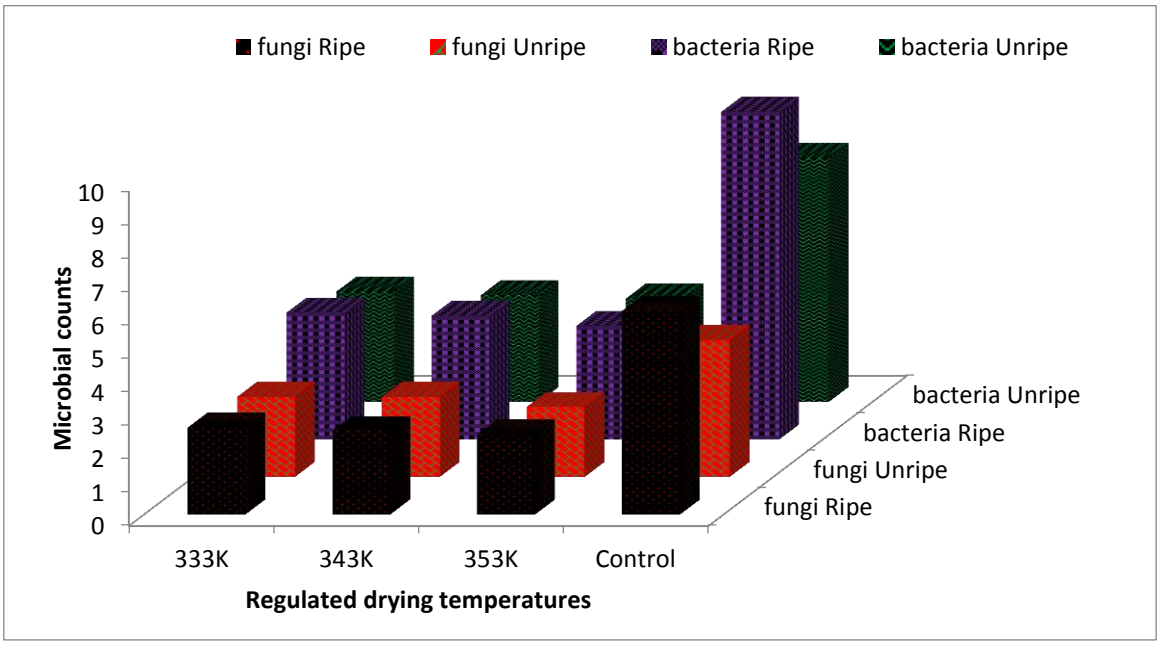


Fig. 9 Microbial count of the samples at various regulated drying temperature

IV. CONCLUSION

Experimental investigations have been carried out to study the effects of drying on ripe and unripe samples of plantain. The plantain samples were subjected to drying at different regulated

temperatures of 333K, 343K, and 353K. The effects of the drying temperature on the ripe and unripe plantain samples were explored.

It was observed that heat affect the percentage amount of fat, crude fibre, ash, protein, and carbohydrate in the plantain samples; the percentage amount of moisture content, carbohydrate and crude fibre decreases when the regulated drying temperatures increase while the amount of protein, fat and ash increases as the regulated drying temperatures increase.

It also was observed that the microbial counts (bacteria and fungi) are higher in the unripe plantain samples than the ripe samples, which mean that the unripe plantain samples have better preservation than the ripe one.

CONFLICTS OF INTEREST

There are no conflicts to declare.

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