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INVESTIGATION OF THE EFFECT OF TEMPERATURE ON THE RATE OF DRYING MOISTURE AND CYANIDE CONTENTS OF CASSAVA CHIPS USING OVEN DRYING PROCESS

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ABSTRACT

This research was aimed at investigating the effect of temperature on the rate of drying moisture and cyanide contents of cassava chips using oven drying process. Five varieties of raw cassava (Manihot Esculenta, Crantz) namely TMS 98/0510, TME 419, TMS 97/2205, NR 87184 and TMS 96/1632 were harvested at twelve (12) months after planting (MAP) from the experimental plots of the Enugu State College of Agriculture and Agro-Entrepreneurship Iwollo-Ezeagu Enugu, Nigeria. For each of the varieties 2kg of tubers were processed. The results from the research showed that processing of the cassava tubers into dried cassava chips using oven process resulted in an acceptable level of moisture and cyanide contents which were in conformity with *the compositional requirements for dried cassava chips. The graph showed that higher the temperature, the faster the rate of drying of the chips. Moreover, the drying rates, moisture and cyanide contents were affected by the drying temperatures.*

Key words: Cassava, Moisture, Drying, Chips, Cyanide.

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1. INTRODUCTION

Cassava, (*ManihotEsculenta,Crantz)* is a tuberous starchy root crop of the family *Euphorbiaceae*(Kochlar, 1981). It is a popular crop worldwide. It is known for drought tolerance and for thriving well on marginal soils, a cheap source of calories intake in human diet and a source of carbohydrate in animal feed (Kordylas, 2002). It is believed to be originally native of South America. It grows well in areas with annual rainfall of 500 - 5000 mm and full sun, but it is susceptible to cold weather and frost (Agodzo and Owusu, 2002).

In recent times due to global interest in cassava, there has been considerable research on the improved genetic component of cassava in Nigeria. The Integrated Cassava Project coordinated by the International Institute of Tropical Agriculture (IITA), National Root Crops Research Institute (NRCRI), Root and Tuber Expansion Program (RTEP) and other stakeholders, led to the release of twelve (12) improved cassava varieties in September 2005 by the National Release Committee under the Federal Ministry of Agriculture. These improved varieties; (TMS 98/0510, TMS 98/0581, TMS 98/0505, TMS 97/2205, TME 419, TMS 92/0326, TMS 96/1632, TMS 98/0002, TMS 92/0057, NR 87184, TMS 96/1089, and NR 930199) are resistant/tolerant to cassava mosaic diseases (which is a common cassava disease in the Niger Delta region), and other major pests and diseases of cassava, such as bacterial blight, anthracnose, cassava green mite, and cassava mealybug. The other benefits of these improved varieties are: high yielding (25 - 40 t/ha compared to the old variety with average yield of 10 - 12 t/ha), early maturing (about 10 - 12 months compared to 18 to 24 months for the old varieties) suitable for food, industry, and livestock feed (Ayodele*et al*., 2011).

Cassava is also classified on the basis of cyanide content into “sweet” and “bitter” varieties. Any variety with cyanide level less than 50 mg/kg is referred to as sweet variety; while those with 100 mg/kg fresh weights and above are referred to as bitter varieties. The bulk of cassava produced in the forest and savannah ecologies of Nigeria are the bitters. The designation of bitter and sweet varieties of cassava depends on the associated levels of toxicity (Nambisan*et al.,* 1987). Consumption of cassava products with high cyanogens levels may cause acute intoxications (Mlingi*et al.,* 1994), aggravate goiter (Bardbury*et al.,* 1982) and, in severe circumstances, induce paralytic diseases (Tylleskar*et al.,* 1992). To avoid dietary cyanide exposure, the glycosides and their metabolites, collectively known as cyanogens, must be removed by processing before consumption. The World Health Organization (WHO) has set the safe level of cyanogens in cassava flour at 10 mg/kg *d.w* (FAO/WHO, 2005), and the acceptable limit in Indonesia is 40 mg/kg *d.w* (Djazuli and Bradbury, 1999). Effective cassava processing methods disintegrate the root tissue completely, thereby releasing an endogenous enzyme, linamarase; this endogenous β-glucosidase enables the hydrolysis of linamarin into glucose and ace-tone cyanohydrins

(Conn, 1981). Many different methods have been developed over hundreds of years to improve processing of cassava roots, resulting in less residual cyanide (Padmaja, et al, 1995). Some methods remove nearly all residual cyanogens (Nambisan and Sundaresan, 1987) but many methods leave appreciable amounts of cyanogens behind (Mlingi and Bainbridge, 1994).

Therefore cassava tubers must be processed as soon as possible after harvest to stop the physiological process and the subsequent deterioration. The processing is undertaken to detoxify the cassava product, reduce the hydrocyanic acid which is dangerous to human consumption, improve its palatability and convert it to a storable form (Dzisi, 1994). One popular method of processing cassava into a storable form is processing into cassava chips. The traditional method of processing cassava into chips consists essentially of peeling the tubers, slicing the tubers and then sun drying. The chips are spread out in the sun on sunny days to ensure drying (Dzisi 1994). Hence drying is adopted in this study, as an effective method of processing cassava into a storable form (processing into dried chips).

Among the problems limiting utilization and consumption of cassava is the rapid spoilage of the roots after harvesting (Kajuna *etal.,* 2001). After harvesting, cassava tubers are susceptible to spoilage and begin to deteriorate in about 48 hours if no preservative measures are taken. According to FAO (2011) between 35% and 40% of cassava produced in Nigeria are lost through postharvest losses accounting for between 3.5 million tons to 4 million tons annually. This account for between 875 tonnes to one million tons of cassava chips worth about $200 million annually.

Drying techniques vary among farmers and range from sun drying to artificial hot-air or oven drying. Drying allows safe storage of cassava chips over a long period by reducing the biological degradation rate of raw cassava chips. It also results in a considerable reduction in weight and volume, which helps minimize packaging, storage and transportation costs.

Quality and the drying time of cassava chips in the sun-drying process are influenced by the chips' geometry and the weather conditions.

Despite the cost of the oven drying, it is more efficient than the conventional sun-drying due to the control over the drying atmosphere and better control of quality to reduce contamination. The rate of drying depends on the chip size, loading density and initial moisture. The air temperature for the production of cassava chips in oven drying is in the range 45–165 °C (Udoro et al., 2008). Therefore, oven drying of cassava chips is highly recommended. In order to obtain a sellable product, dried cassava chips should pass the following criteria: starch content (68–70% minimum), final moisture content (14–17%), fiber content (5% maximum) and sand content (3% maximum).

Pornpraipech et al. (2017) investigated the drying behavior of cassava chips using two cutting shapes—rectangular and circular—with evaluation under different air temperatures of 60 °C, 80 °C, 100 °C and 120 °C. The results showed that the rectangular chips with a drying air temperature of 100 °C was optimal because they had a soft, white color desirable for cassava flour manufacture and required less drying time compared to the circular chips Four classical drying models—Approximation of Diffusion, Henderson and Pabis, Page, and Verma—were fitted to experimental data and evaluated by comparing the coefficient of determination, reduced chi-square and root mean square error between the experimental and predicted values.

Sanni et al. (2015) developed a conductive rotary dryer (CRD) for the drying of pulverized cassava meal with a view to mechanizing the traditional sun-drying method. The effects of four parameters of the dryer were investigated and optimized using the Taguchi technique. Drum temperature had the most significant effect on the swelling index of the cassava meal with signal-to-noise ratio difference of 3.16. A swelling index of 1.02 was predicted for cassava meal dried at drum temperature of 140^0C, vapor extraction rate of 0.03 m^3/sand 8 kg of wet cassava meal per batch. The moisture content of the cassava meal decreased from 45 % to 10 % (wet basis) in an average of 44 minutes and the proximate composition of the dried cassava meal met the standard specification recommended for cassava flour. The application of the CRD was better than traditional sun drying and its injection into the cassava processing industry can contribute to agro-industrial growth in cassava producing countries of Africa.

Quick drying of cassava is advantageous in the sense that the risks of contamination and mould growth are minimized. In general, the faster a food is dried, the better the quality of the dried product in terms of better flavor, colour, texture and higher nutritional value. Therefore, the need for innovative and timely processing of cassava into chips for subsequent production of cassava flour as food materials (food stuffs) for local delicacies and mass production of starch and other cassava based products which can be exported thereby boosting the nation's economy, is required. Hence, the need to evaluate the moisture and cyanide contents of cassava chips using different drying technologies

The study is aimed at investigation of the effect of temperature on the rate of drying moisture and cyanide contents of cassava chips using oven drying process.

2. MATERIAL AND METHODS

2.1. Materials and equipment used

Five varieties of raw cassava *(Manihot Esculenta, Crantz)* namely TMS 98/0510, TME 419, TMS 97/2205, NR 87184 and TMS 96/1632 were harvested at twelve (12) months after planting (MAP) from the experimental plots of the Enugu State College of Agriculture and Agro-Entrepreneurship Iwollo-Ezeagu Enugu, Nigeria. For each of the varieties 2kg of tubers were processed. The following equipment, reagent and chemical were used for the study;

2.1.1. Reagents and chemicals:

- Sulphuric acid (H_2SO_4)
- Sodium - hydroxide (NAOH)
- Boric acid
- Bromo - Crisol green
- Hydrochloric acid (HCl)
- N - hexane
- Acetone
- Petroleum ether
- 2,6 - dichlorophenolindophenol (DCP)
- Picric acid
- KCN (Potasium cyanide)

2.1.2. Equipment

- Laboratory electric dry oven (DHG-9101-1SA [75L] GALLENKOMP made in England)
- Anemometer
- Hygrometer

- Mercury-in-glass-thermometer (0^0C - 360^0C)
- Digital scale (Pioneer/Ohaus NO: PA213 made in China)
- Stopwatch
- Laboratory glass desiccators
- Sharp stainless knife
- Rake
- Micrometer screw gauge
- Wire gauze
- Spectrophotometer (Cam Spec Model A413)
- Atomic Absorption Spectrophotometer (Buck Scientific 210 VGP)
- Kjeldahl flask
- Soxhlet apparatus
- Muffle furnace (Carbolite CWF 1200)
- Platinum crucible
- Filter papers
- Ram bottom flasks
- Conical flasks
- Beakers

2.2. Processing of cassava chips

2.2.1. Oven drying process

The processing of the cassava chips followed the traditional method described by Akingbala*et al*., (1991). The cassava varieties (tubers) were washed with clean water and allowed to drain or dry. The fresh cassava root were manually peeled and rewashed with clean water then chipped using a sharp stainless knife and micrometer screw gauge for measuring the adequate size of about 5 cm by 3 cm with thickness of about 0.2 cm. The chips were sorted to get uniform sizes after which the weight of each sample was taken, dried at a particular temperature and time then cooled in a dessicator and reweighed to determine loss in weight, moisture content, percentage moisture content, drying rate and cyanide content.The drying was done by varying temperature at constant time and varying time at a constant temperature as shown in Tables 3.2 and 3.3 respectively. The cassava chips were separated into samples (A – E), according to the five cassava species used in this study.

Sample A	-	TMS 98/0510
Sample B	-	TME 419
Sample C	-	TMS 97/2205
Sample D	-	NR 87184
Sample E	-	TMS 96/163

2.3. Determination of moisture content

The moisture content was determined on the basis of weight loss according to Lazzari (1994); Chauynarong (2015) using the formula;

$$MC = \left[{(W_i - W_f)}/{W_i}\right] \quad (3.1)$$

Where; $MC = moisturecontent$

$$W_i = initialweight, \qquad W_f = finalweight$$

A sample of the cassava chips was first weighed using the laboratory digital scale. The initial mass of the sample was obtained (Wet basis),the same was then mashed to extract some of its moisture, the sample was then dried further in an oven at 100^{0}C in a record time interval, until no mass reduction or negligible weight difference, the sample was brought out, cooled in desiccator and reweighed. The dry weight was obtained (dry basis) thus; if the initial mass of the sample was obtained as 42.38 grams (wet basis), and the dry weight was obtained as 18.495 grams (dry basis) [when there was no more mass reduction]. From the above equation, the moisture content was obtained as;

$$\frac{42.38-18.495}{42.38} = mc \quad (3.2)$$

The dry matter content is determined by multiplying equation (3.2) by 100%

This implies that the dry matter content is (100 – 56.3) % = 43.7%

The moisture content of the final dried mass was obtained the same way, i.e. laboratory test to ensure the non-interference of dust and other particles which add to the mass and hence would affect computational analysis of the final moisture content (Ola et al, 2001).

2.4. Determination of the percentage moisture content

According to Youcef-Ali *et al*., (2001), percentage moisture content is determined as moisture content expressed as a percentage (%) either on a wet basis or a dry basis equations (3.3 and 3.4)

$$MC_{wb} = \left({W_{tw} - W_{tdm}}/{W_{tw}}\right) \times 100 \ (3.3)$$

$$MC_{db} = \left({W_{tw} - W_{tdm}}/{W_{tdm}}\right) \times 100 \ (3.4)$$

MC_{wb} =moisture content on a % wet basis
MC_{db} =moisture content on a % dry basis
W_{tw} =weight of water weight of dry matter
W_{tdm} =weight of dry matter

2.5. Proximate analysis of the cassava species

Proximate composition of the fresh and dried cassava chips were determined according to standard AOAC, (1990) methods.

2.5.1. Moisture content

Moisture content was determined by using the oven drying method as described by the standard of Association of Official Analytical Chemists (AOAC, 1990). 5g of the sample was weighed to a constant weight in an air-oven at 100°C for 6hrs and the result was expressed as the percentage difference in weight.

2.5.2 Dry matter

Dry matter content was calculated from the formula:

$$100 - C \qquad (3.5)$$

where; $C = moisture\ content\ (mc)$ (3.6)

2.7. Determination of cyanide content

The total cyanide content of fresh and dried cassava chips samples was determined by the colorimetric Alkaline Picrate method of Ikediobi *et al.*, (1980) as modified by Onwuka (2005). The yellowish alkaline picrate solution was obtained by dissolving 1g picric acid and 5g Na_2CO_3 in distilled water. The liquid extract filtrate (1.0 ml) from the cyanide extraction process was added to 4.0ml alkaline picrate solution in a test tube and corked. The mixture was incubated at 50^0C for 5 minutes to allow for colour development. After colour development (from yellowish colour to reddish colour) and cooling, the absorbance was read at 490 nm wavelength with UV/visible spectrophotometer (Jenway 6405, England). Diluted potassium cyanide (KCN) was used to prepare the standard curve that was employed to calculate the cyanide content of the experimental samples.

2.8. The effect of temperature on drying of the cassava chips at a constant time in oven drying

2.8.1. The effect of temperature on the moisture contents of the cassava chips

The effect of the drying temperatures on the percentage moisture contents of the cassava chips at a constant drying period of 70 minutes is shown in Figure 3.1.

Table 2.1 Formulae for the drying rate calculation at constant time.

Temperature T(^{0}C)	Weight of the sample WS (g)	Loss in the weight of the sample WL (g)	Moisture content MC(g)	Percentage moisture content MC(%)	Drying rate DR(g/min)	Cyanide content CC(mg/g)	Drying time t(min)
30	WS_O	$-$	$WS_O - WS_7$	$\left({MC_O}/{WS_O}\right) \times 100$	$-$	$(CC)_O$	0
40	WS_1	$WS_O - WS_1$	$MC_O - WL_1$	$\left({MC_1}/{WS_1}\right) \times 100$	$\frac{WL_1}{t}$	$(CC)_1$	60
50	WS_2	$WS_O - WS_2$	$MC_O - WL_2$	$\left({MC_2}/{WS_2}\right) \times 100$	$\frac{WL_2}{t}$	$(CC)_2$	60
60	WS_3	$WS_O - WS_3$	$MC_O - WL_3$	$\left({MC_3}/{WS_3}\right) \times 100$	$\frac{WL_3}{t}$	$(CC)_3$	60
70	WS_4	$WS_O - WS_4$	$MC_O - WL_4$	$\left({MC_4}/{WS_4}\right) \times 100$	$\frac{WL_4}{t}$	$(CC)_4$	60
80	WS_5	$WS_O - WS_5$	$MC_O - WL_5$	$\left({MC_5}/{WS_5}\right) \times 100$	$\frac{WL_5}{t}$	$(CC)_5$	60
90	WS_6	$WS_O - WS_6$	$MC_O - WL_6$	$\left({MC_6}/{WS_6}\right) \times 100$	$\frac{WL_6}{t}$	$(CC)_6$	60
100	WS_7	$WS_O - WS_7$	$MC_O - WL_7$	$\left({MC_7}/{WS_7}\right) \times 100$	$\frac{WL_7}{t}$	$(CC)_7$	60

Table 2.2 Formulae for the drying rate calculation at constant temperature.

Time T(min)	Weight of the sample WS (g)	Loss in the weight of the sample WL(g)	Moisture content MC(g)	Percentage moisture content MC(%)	Drying rate DR(g/min)	Cyanide content CC(mg/g)	Temperature T(^{0}C)
t_0	WS_O	-	$WS_O - WS_7$	$\left(^{MC_O}/_{WS_O}\right) \times 100$	-	$(CC)_O$	30
t_1	WS_1	$WS_O - WS_1$	$MC_O - WL_1$	$\left(^{MC_1}/_{WS_1}\right) \times 100$	$\frac{WL_1}{t_1 - t_0}$	$(CC)_1$	100
t_2	WS_2	$WS_O - WS_2$	$MC_O - WL_2$	$\left(^{MC_2}/_{WS_2}\right) \times 100$	$\frac{WL_2}{t_2 - t_0}$	$(CC)_2$	100
t_3	WS_3	$WS_O - WS_3$	$MC_O - WL_3$	$\left(^{MC_3}/_{WS_3}\right) \times 100$	$\frac{WL_3}{t_3 - t_0}$	$(CC)_3$	100
t_4	WS_4	$WS_O - WS_4$	$MC_O - WL_4$	$\left(^{MC_4}/_{WS_4}\right) \times 100$	$\frac{WL_4}{t_4 - t_0}$	$(CC)_4$	100
t_5	WS_5	$WS_O - WS_5$	$MC_O - WL_5$	$\left(^{MC_5}/_{WS_5}\right) \times 100$	$\frac{WL_5}{t_5 - t_0}$	$(CC)_5$	100
t_6	WS_6	$WS_O - WS_6$	$MC_O - WL_6$	$\left(^{MC_6}/_{WS_6}\right) \times 100$	$\frac{WL_6}{t_6 - t_0}$	$(CC)_6$	100
t_7	WS_7	$WS_O - WS_7$	$MC_O - WL_7$	$\left(^{MC_7}/_{WS_7}\right) \times 100$	$\frac{WL_7}{t_7 - t_0}$	$(CC)_7$	100

10. RESULTS AND DISCUSSION

The effect of the drying temperatures on the percentage moisture contents of the cassava chips at a constant drying period of 70 minutes is shown in Figure 3.1.

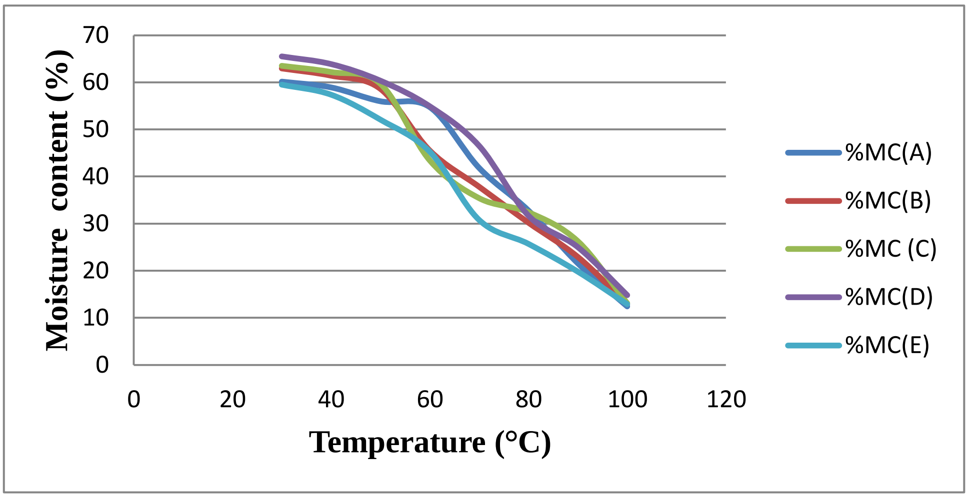

Figure 3.1 The effect of temperature on the moisture content of the cassava chips at a constant time in oven drying.

It can be seen that the drying temperature is one of the key factors that affects the rate of moisture removal of the cassava chips in oven drying. The greater the temperature difference between the drying air and the food, the greater the heat transfer to the food. This shows that heat was actually needed to dry the cassava chips. The moisture content decreased steadily with the increase in temperature i.e. higher temperature favored moisture removal from the cassava chips. At low temperature, the moisture content remained unchanged after the drying period. The relationship between the moisture contents and the temperatures were almost the same for the five species of the cassava chips. The original moisture contents for the five species of the cassava chips were almost the same except the original moisture contents of species D (65.50%) was higher than that of the other species, while species E contains the least amount (59.50%). Another important deduction from the graph, is that the originalmoisture contents of the five species of the cassava chips samples were finally reduced to the critical values of; 12.42%, 12.94%, 13.10%, 14.81%, and 12.90% respectively (hence they were obtained at the peak of the drying temperatures). More so, the result agrees with the report by Dzisi, (1994) that cassava chips have to be dried to moisture contents of around 12 to 15%; from the original moisture content of about 65 to 75%. Nevertheless the difference in the original moisture contents could be attributed to the chemical compositions of the cultivars (Nwabanne, 2008).

3.2.2. The effect of temperature on the drying rate of the cassava chips

The rate of drying of the cassava chips was affected by the drying temperatures. This can be seen in Figure 3.2.

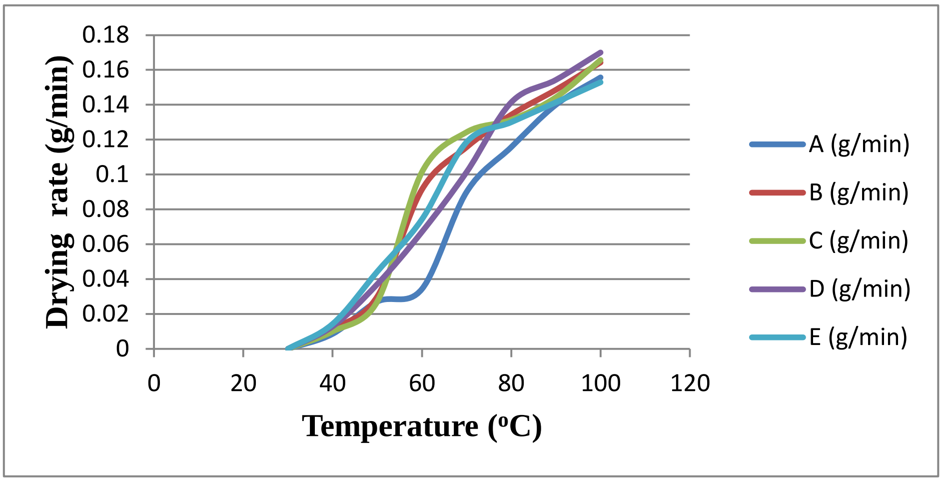

Figure 3.2 The effect of temperature on the drying rate of the cassava chips at a constant time in oven drying.

Temperature had significant effects on the drying rate of the cassava chips. The drying rate increased as temperatures increases. This shows that heat transfer is needed to effect the change. The rate at low temperature was lower, showing that drying is faster when the temperature is around 100°C (crital point). This would suggest that drying rate was dependent on temperature as had been earlier reported by other researchers (Abraham *et al.*, 2004; Velic*et al.*, 2007 Ajala*et al.*, 2011). All the cultivars exhibited different drying characteristics. This is attributed to the difference in the chemical composition of the cultivars (Nwabanne, 2008). In addition, the results also showed that the peak of the drying rates for samples A to E (0.1557, 0.1643, 0.1657, 0.1700, 0.1529) g/min respectively were obtained at the critical temperatures. Although sample Dhad the maximum drying rate of 0.1700 g/min while samples A and E had the minimum drying rates of (0.1557and 0.1529) g/min respectively.

3.2.3. The effect of temperature on the cyanide content of the cassava chips

The cyanide content was a function of the temperatures. The cyanide contents decreased with the temperature of drying. This effect of temperature on the cyanide content is shown in Figure 3.3.

Observation from the results showed that species D and E originally had the maximum and minimum cyanide contents of 0.08980 mg/g and 0.02350 mg/g respectively. From the behavior of the graphs, the shapes of the cyanide contents for the five species of the cassava chips are almost the same except the shape of sample D that is a little separated from the other because it had the highest cyanide content originally. However, the cyanide content of all the species decreased at a temperature below 50^0C and remained almost constant thereafter.

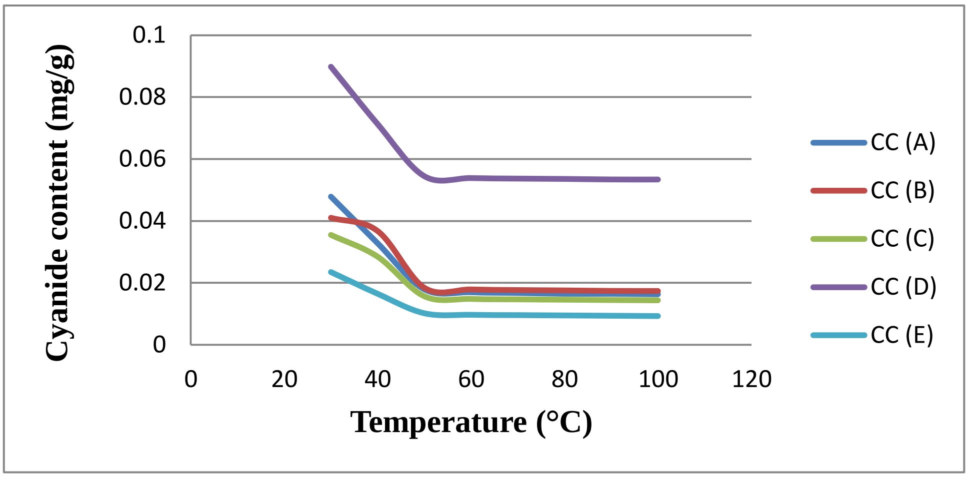

Figure 3.3 The effect of temperature on the cyanide content of the cassava chips at a constant time in oven drying.

This observation is in agreement with report by Nambisan, (1994) that during oven-drying, an increase in drying temperatures is accompanied by an increase in cyanide retention. At drying temperatures above 55^0C, linamarase activity is inhibited and therefore, linamarin starts to accumulate in dried cassava chips. Hence, linamarase action (cyanogen degradation/cyanide content reduction) is optimal at temperatures below 55^0C. In addition, it is pertinent to observe that the cyanide retention of species A to D are different from the recommended value 0.01000 mg/g (ARS 839: 2012), which could be attributed to the higher drying temperatures of the chips except specie E that had (0.00930 mg/g) cyanide retention which is close to the recommended value and by virtue of its original cyanide content.

3.3.1. The effect of the drying time on the moisture content of the cassava chips

The duration of the drying is an important factor of drying. The effect of time on the percentage moisture contents of the chips at a constant drying temperature of 100^0C is shown in Figure 4.4

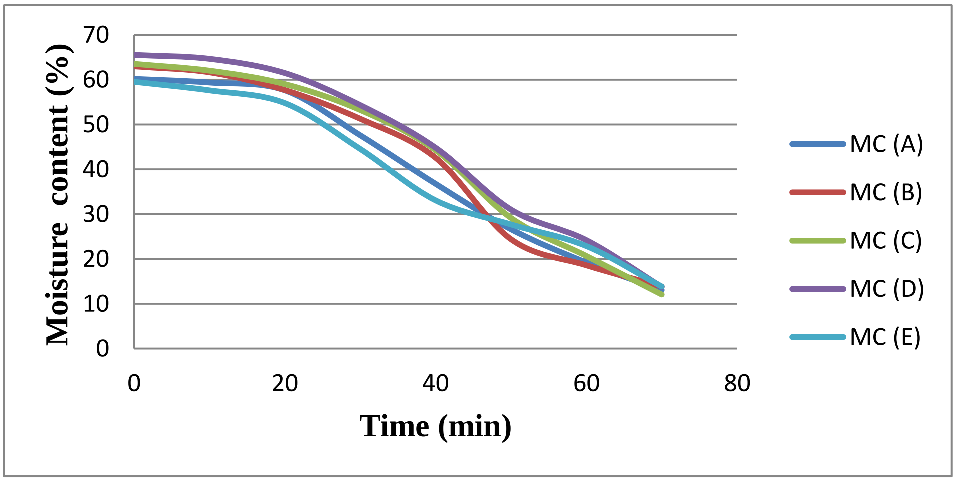

Figure 3.4 The effect of the drying time on the moisture content of the cassava chips at a constant temperature in oven drying.

It was discovered that as the drying time increased, the moisture content decreased in all the samples till it reached equilibrium. This shows that the duration of the drying must be put into consideration when drying the cassava chips. From the graphs, the chips exhibited sharps falling rate gradients which is mainly controlled by the internal factor of diffusion mechanisms in the chips. Another important deduction from the graph, is that the original moisture contents of the five species of the cassava chips samples were finally reduced to the critical values of; 13.04%, 13.84%, 12.05%, 13.75%, and 13.83% respectively (hence they were obtained at the peak of the drying time). More so, the result agrees with the report by (Dzisi, 1994) that cassava chips have to be dried to a moisture contents of 12 to 15%; from the original moisture content of about 65 to 75%. This difference in the original moisture contents could be attributed to the chemical compositions of the cultivars (Nwabanne, 2008). Another important observation from the graphs is that the shapes of the original moisture contents for the five species of the cassava chips are almost the same. However, species D and E had the maximum and minimum original moisture contents of 65.50% and 59.50% respectively.

3.3.2. The effect of the drying time on the drying rate of the cassava chips

The rate of drying was affected by the drying time. The effect of the drying time on the rate of drying is shown in Figure 3.5.

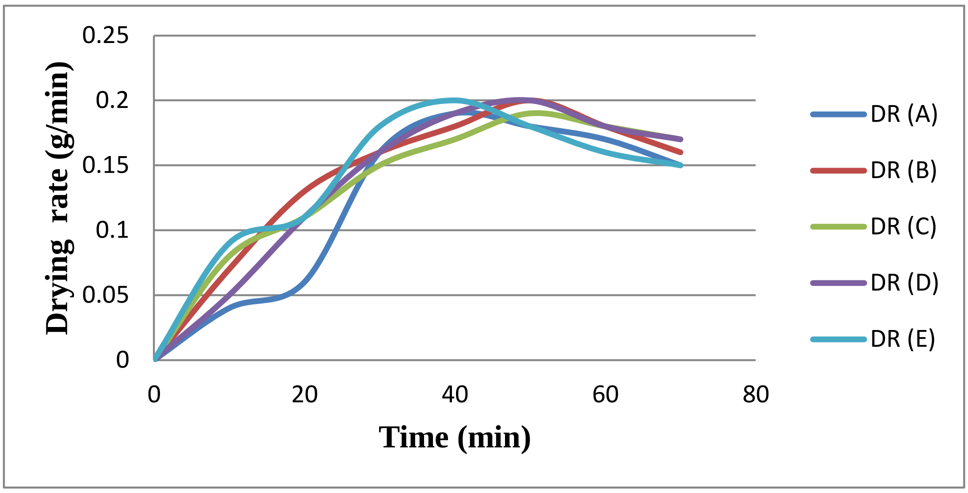

Figure 3.5 The effect of the drying time on the drying rate of the cassava chips at a constant temperature in oven drying.

The drying rate of the chips increases with the time of drying at a constant temperature. The behavior of the drying rate curves for the five species of the chips show that, as the drying time increases, the drying rate of the chips increase steadily after (10 - 50) minutes in almost all the cases, and exhibited a sharp falling rate gradient towards 60minutes and the peak of the drying time. All the cultivars exhibited different drying characteristics. This is attributed to the difference in the chemical composition of the cultivars (Nwabanne, 2008). Another important observation from the graph is that samples A and E attained its maximum drying rates of (0.19 and 0.20) g/min respectively at 40 minutes of the drying time while samples B, C and D attained its peak drying rates at 50 minutes of the drying time. In addition, it was observed that samples B, D and E had the highest drying rate of 0.20 g/min respectively while samples A and C had the minimum drying rates of 0.19g/min respectively.

3.3.3. The effect of the drying time on the cyanide content of the cassava chips

The effect of drying time on cyanide content is shown in Figure 4.6.If the chips are heated continually, the cyanide content remains the same irrespective of the drying time. Therefore, the cyanide content of the chips was solely a function of the drying temperatures and was not affected by the drying time. This assertion could also be seen from the behavior of the graph, for the five species of the cassava chips except that the cyanide content of specie D (0.05339 mg/g) was higher than that of the other species while specie E has the lowest cyanide content (0.00930 mg/g). In addition, it is pertinent to observe that the cyanide retention of species A to D are different from the recommended value 0.01000 mg/g (ARS 839: 2012), which could be attributed to the fact that the cyanide contents of cassava chips was solely a function of the drying temperatures and was not affected by the drying time except specie E that had (0.00930 mg/g) cyanide retention which is close to the recommended value, as a result of its original cyanide content.

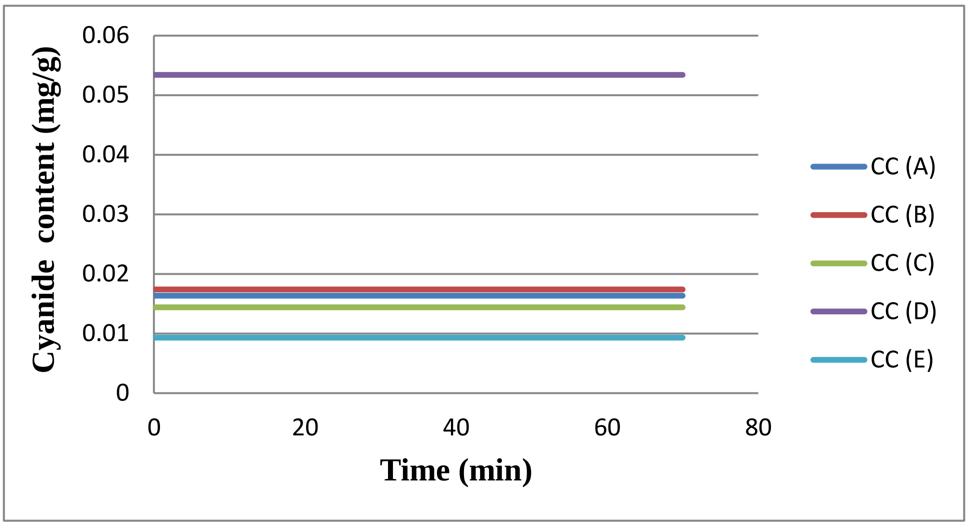

Figure 3.6 The effect of the drying time on the cyanide content of the cassava chips at a constant temperature in oven drying

4. CONCLUSIONS

Cassava cannot be stored for long in the fresh form after harvesting because of quick perishability of the roots, in the addition to its high moisture content and toxic substance it contains (hydrocyanic acid). Therefore, there is need for improved methods of processing that will greatly reduce the moisture and cyanide contents to an acceptable level. Based on these facts, post-harvest losses due to deterioration of the cassava tubers could be reduced to the bearable minimum by processing of the cassava tubers into dried cassava chips.

However, the results from this research showed that processing of the cassava tubers into dried cassava chips using oven process resulted in an acceptable level of moisture and cyanide contents which were in conformity with the compositional requirements for dried cassava chips. The higher the temperature, the faster the rate of drying of the chips. Moreover, the drying rates, moisture and cyanide contents were affected by the drying temperatures.

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