International Scholars Journals

International Journal of Agricultural Extension and Rural Development Vol. 8 (4), pp. 001-007, April, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals



*Full Length Research Paper*

# The drying effect of colour light frequencies on the nutrient and microbial composition of cassava

**O.M. Kolawole[1]*, B. J. Adeyemi[1], R. M. O. Kayode[2] and T. B. Ajibola[3].**

[1]Department of Microbiology, University of Ilorin, P.M.B 1515 Ilorin, Kwara State, Nigeria.
[2]Division of Biotechnology, Department of Food Science and Home Economics, P.M.B 1515, University of Ilorin, Ilorin, Kwara State, Nigeria.
[3]Department of Physics, University of Ilorin, P.M.B 1515 Ilorin, Kwara State, Nigeria.

Accepted 15 February, 2019

**The drying effect of varying light frequencies on the proximate and microbial composition of cassava was investigated. Drying was carried out using the solar fabrication designed by the Department of Physics, University of Ilorin. The results of the various physicochemical parameters revealed significant difference between the mean temperatures of the colour frequencies compared with the control ($p < 0.05$). The colour black recorded the highest moisture content (67.0%) while deep purple had the lowest (57.0%) . The results of the proximate composition showed that deep purple had the highest crude protein content (4.21%), black had the highest percentage carbohydrate (92.64%) and white had the highest vitamin C content as compared with the control. Also deep orange (3.03%), deep yellow (0.72%) and light purple (2.79%) had the highest crude fat, crude fibre and ash respectively compared with the control. It was revealed that these colours were significantly different ($p<0.05$) from the control. A total of 6 bacterial species were isolated from cassava. These are *Staphylococcus aureus, Staphylococcus epidermidis, Micrococcus luteus, Lactobacillus lactic, Lactobacillus brevis* and *Proteus vulgaris.* The total bacterial count was highest in light brown and lowest in deep yellow. The bacterial isolates were widely distributed in light green (5) and least in light blue and the control (2). The 5 fungi isolated from the cassava are *Aspergillus niger, Aspergillus flavus, Rhizopus stolonifer, Mucor racemosus* and *Fusarium oxysporium.* The fungal isolates were widely distributed in white (4) and least in black (1).**

**Key words:** Drying, frequencies, cassava, proximate, microbial.

## INTRODUCTION

Drying is an excellent way to preserve food; solar drying is one of the oldest agricultural techniques related to food preservation. Drying preserves food by removing enough moisture from the food to prevent decay and spoilage. If the temperature is too low at the beginning, microorganisms may grow before the food is adequately dried.

Cassava is a plant that originated from South America and is known under various names: *Manihot esculenta*, ”manioc”, ”yucca” and ”ege” (in western Nigeria). Accord-ing to the Food and Agriculture Organization of the Uni-ted Nations Global Cassava Development Strategy, Cas-sava is the third most important source of calories in the tropics, after rice and corn (FAO, 2004). Cassava tubers are rich in carbohydrates, mainly starch, with fresh root containing about 30% starches and very little protein (Cock, 1985).

The cassava plant gives the highest yield of food energy per cultivated area per day among crop plants. With the exception of sugar cane, cassava is the highest source of carbohydrate, and it contains significant amo- unts of calcium (50 mg/100g), phosphorus (40 mg/100g) and vitamins C (25 mg/100g). Cassava tubers are how-ever, deficient in protein, fat, some minerals and vitamins (Onwueme, 1978; IITA, 1996).

At harvest, cassava is characterized by high moisture and low protein contents.

Fresh cassava roots suffer very heavy losses when stored for more than a few days. These losses are not caused by insects (pests) but by microbial infection and physiological factors. Post-harvest storage of cassava has been a major problem for production, marketing, utilization and industrialization. Hitherto, it is a general belief

*Corresponding author. E-mail: tomak74@yahoo.com. Tel.: +234-8060088495.

that fresh cassava roots cannot be stored for more than a few days. Two major problems that arise during preservation are microbial rotting and internal discolouration, which renders cassava chips unacceptable for human consumption (NSPRI, 1983; IITA, 1996).

Raw cassava contains cyanogenic glycosides, particularly linamarin and lotaustralin, which are converted to prussic acid and hydrogen cyanide (HCN) when they come in contact with linamarase, an enzyme that is released when the cells of cassava root are ruptured (O'Brien et al., 1991). Drying of cassava root is an important step in reducing weight and microbial spoilage since otherwise they deteriorate rapidly (Rowland, 1993). Fermenting is important in reducing cyanogenic glycosides and lowering of pH. Drying, grinding and cooking associated with cassava flour products are effective in detoxifying the bitter varieties (O'Brien et al., 1991).

The nutritional value of food is only minimally affected by drying. Vitamin A is retained during drying; however, because vitamin A is light sensitive, food containing it should be stored in dark places. Vitamin C is destroyed by exposure to heat, although pretreatment of foods before drying increases the Vitamin C content (David and Whitfield, 2000).

Dried foods are high in fiber and carbohydrate and low in fat, making them healthy food choices. Dried foods that are not completely dried are susceptible to mold. Microorganisms are effectively killed when the internal temperature of food reaches about 63°C. Reducing the moisture content to between 10 and 20% prevents bacteria, yeast, mold and enzymes from spoiling food. The flavor and most of the nutritional value is preserved and concentrated. The amount of sunlight and relative humidity determines how quickly the food dries. Some other variables include air movement, quantity and type of food (David and Whitfield, 2000).

The wavelength of the rays of sunlight used for drying consists of a broad spectrum (Wikipedia, 2007). Although the spectrum is continuous, there are no clear boundaries between one color and the next. The electromagnetic spectrum is made up of rays of light that are damaging to microorganisms and will affect the bacterial count observed in any food sample at a given time.

Traditional sun drying often yield poor quality, since the produce is not protected against dust, rain and wind, or even against insects, rodents, birds and domestic animals while drying. In this study, these problems are tackled by the use of a fabricated enclosed container for drying cassava, thereby minimizing the risk of soiling, contamination with microorganisms, formation of mycotoxins and infections that would have resulted from disease-causing germs.

In this study, drying was carried out using a solar fabrication designed by the Department of Physics, University of Ilorin, Nigeria. The proximate compositions of cassava were analyzed by the methods described by AOAC (2000). Bacterial count and characterization was observed and the fungal identification was also carried out using the procedures recommended by Fawole and Oso (2004).

## MATERIALS AND METHODS

### Collection of samples

Cassava roots were uprooted fresh from a farm behind the Chapel of Light, University of Ilorin, Nigeria. The roots were healthy and free from all forms of mechanical injury, which might be a possible source of contamination.

### Preparation of sample for drying

The roots were all properly washed and peeled. The fleshy part were then chopped into pieces; 200 g was placed in a container in one of the holes in the fabricated wooden box, covered properly with a white textile material, corked properly and left in the sun to dry. The procedure was repeated for other colours that is, black, red, orange, blue, green, purple and brown in duplicates of the light and deep colours of the same textile material while the control was without any covering of cloth material that is, white, black, light brown, deep brown, light red, deep red, light blue, deep blue, light yellow, deep yellow, light orange, deep orange, light purple, deep purple, light green, deep green and control.

### Description of the fabrication used for drying

The fabrication is a long wooden box with 8 holes. Plastic containers were then placed in the drilled holes, which have perforations at the sides and base. The inside was coated black. The black colour inside the bucket is a good absorber and poor reflector of heat and light. The perforations at the base and side of the bucket are to prevent the accumulation of water and enable free flow of air. The cassava to be dried was placed at the base of the bucket. The bucket was covered with a cloth material and then placed in the hole.

### Wavelengths of the light rays on the cloth material

The following ranges were used as an approximation:

1. Violet (380 – 450 nm)
2. Blue (450 – 495 nm)
3. Green (495 – 570 nm)
4. Yellow (570 – 590 nm)
5. Orange (590 – 620 nm)
6. Red (620 – 750 nm)

### Determination of temperature

Mercury-in-glass thermometer was used to measure the temperatures of each of the cassava samples by placing the thermometer in the holes at the side of the container. It was left for about 3 min before the readings were taken. Readings were taken at intervals of 3 h throughout the drying period. The mean values of the temperatures were then calculated and the level of statistical significance determined at $p<0.05$.

### Determination of moisture content

The moisture content of cassava was determined using the method described by AOAC (2000).

**Table 1.** Results of the nutrient and vitamin C compositions of dried cassava.

| Sample | % C.P | % C. Fat | % C. Fibre | % Ash | % CHO | % Vit. C |
|---|---|---|---|---|---|---|
| White | 3.76$^{f}$ | 2.00$^{a}$ | 0.68$^{cde}$ | 2.62$^{abc}$ | 90.96$^{bc}$ | 3.16$^{e}$ |
| Black | 2.21$^{a}$ | 1.98$^{a}$ | 0.62$^{abcd}$ | 2.56$^{abc}$ | 92.64$^{i}$ | 2.45$^{d}$ |
| L. brown | 2.42$^{a}$ | 2.08$^{a}$ | 0.66$^{bcde}$ | 2.42$^{abc}$ | 92.43$^{ghi}$ | 1.47$^{ab}$ |
| D. brown | 3.03$^{cd}$ | 1.98$^{a}$ | 0.63$^{abcd}$ | 2.51$^{abc}$ | 91.86$^{efgh}$ | 1.05$^{a}$ |
| L. red | 2.78$^{bc}$ | 1.97$^{a}$ | 0.68$^{cde}$ | 2.62$^{abc}$ | 91.95$^{efgh}$ | 1.85$^{bc}$ |
| D. red | 2.84$^{bcd}$ | 1.96$^{a}$ | 0.66$^{bcde}$ | 2.51$^{abc}$ | 92.04$^{fgh}$ | 3.09$^{e}$ |
| L. blue | 2.84$^{bcd}$ | 1.96$^{a}$ | 0.69$^{de}$ | 2.24$^{a}$ | 92.28$^{ghi}$ | 2.93$^{e}$ |
| D. blue | 2.84$^{bcd}$ | 1.98$^{a}$ | 0.62$^{abcd}$ | 2.39$^{abc}$ | 91.12$^{bcd}$ | 2.11$^{cd}$ |
| L. yellow | 3.74$^{f}$ | 1.97$^{a}$ | 0.58$^{ab}$ | 2.63$^{bc}$ | 91.06$^{bc}$ | 2.89$^{e}$ |
| D. yellow | 3.28$^{e}$ | 2.08$^{a}$ | 0.72$^{e}$ | 2.26$^{ab}$ | 91.66$^{def}$ | 1.32$^{a}$ |
| L. orange | 3.63$^{f}$ | 1.92$^{a}$ | 0.56$^{a}$ | 2.51$^{abc}$ | 91.39$^{cde}$ | 1.93$^{bc}$ |
| D. orange | 3.09$^{de}$ | 3.03$^{c}$ | 0.64$^{abcde}$ | 2.52$^{abc}$ | 91.78$^{efg}$ | 2.11$^{cd}$ |
| L. purple | 3.80$^{f}$ | 1.98$^{a}$ | 0.59$^{ab}$ | 2.79$^{c}$ | 90.85$^{bc}$ | 3.01$^{e}$ |
| D. purple | 4.21$^{f}$ | 2.38$^{b}$ | 0.66$^{bcde}$ | 2.49$^{abc}$ | 90.28$^{a}$ | 3.09$^{e}$ |
| L. green | 2.70$^{b}$ | 2.09$^{a}$ | 0.60$^{abc}$ | 2.59$^{abc}$ | 92.04$^{fgh}$ | 3.11$^{cd}$ |
| D. green | 2.86$^{bc}$ | 2.13$^{a}$ | 0.61$^{abcd}$ | 2.48$^{abc}$ | 91.96$^{efgh}$ | 2.17$^{cd}$ |
| Control | 4.24$^{g}$ | 1.98$^{a}$ | 0.64$^{abcde}$ | 2.46$^{abc}$ | 90.68$^{ab}$ | 3.16$^{e}$ |

Values are mean of three replicates determination. Mean in the same column not sharing a common superscript are significantly different at p< 0.05 while mean sharing the same letter are not significantly different. Key: L- light; D- dark; % C. fibre- percentage crude fibre; % C. Ash - percentage crude ash; % CHO - percentage carbohydrate; % Vit. C percentage vitamin C; % C.P – percentage Crude Protein; % C. Fat- percentage crude fat.

**Determination of proximate composition**

The proximate compositions determined include the % crude protein, fat, fibre, and ash and % carbohydrate. These were all analyzed using the method of AOAC (2000).

**Determination of vitamin C content**

1 ml of glacial acetic acid was added to acidify the filtrate obtained from 5 g of grinded cassava and it was then titrated against dichlorophenol indophenol (DCPIP) dye. The titre value was then read from the burette and the vitamin C content calculated using the method of AOAC (2000).

**Preparation of media**

The materials used such as glass wares were properly sterilized in the oven (Gallenkamp) at 160°C for 1 h. All the media used were prepared according to the manufacturers instructions and then autoclaved at 121°C for 15 min.

**Isolation and characterization of pure cultures of microorganisms**

Isolation and characterization of bacterial and fungal isolates were carried out according to the method of Fawole and Oso (2004). Tentative identification of bacterial isolates was done using the Bergey's Manual of Determinative Bacteriology (Bucchanans and Gibbons, 1974). Fungal identification was carried out according to the procedure described by Samson and Van Reenen-Hoekstra (1982).

**Statistical analysis**

All results are presented as mean ±SEM. Data were analyzed by ANOVA's method of Duncan's multiple range test and results were considered statistically significant at p<0.05.

## RESULTS

The result of the mean temperature during the periods of drying showed that there was significant difference between varying colour frequencies compared with the control. However, there was no significant difference ($p < 0.05$) between the means of the same colour over the 7 days of drying (Figure 1).

The results of the moisture content revealed that there was significant difference among various colour frequencies used in the drying process of Cassava. Black colour recorded the highest moisture content (67.0%), while deep purple recorded the lowest (57.0%) (Figure 2).

Table 1 compared the results of the mean values of the proximate composition of cassava during the drying period. The results revealed that there was significant difference among the % crude protein, carbohydrate and vitamin C, while % crude ash, fat and fibre showed no significant difference.

The result of the % crude protein revealed significant difference (p<0.05) among varying colour frequencies as compared to the control. However, deep purple colour frequencies showed the highest (4.21%) crude protein composition compared to the control. Also, black (92.64%) and white (3.16%) showed the highest % carbohydrate and vitamin C contents respectively as compared with the control. The results also revealed that deep orange (3.03%), deep yellow (0.72%) and light purple

**Table 2.** Distribution of the bacterial isolates in cassava under varying colour light frequencies.

| Sample | No. | *S. aureus* | *S. epidermidis* | *M. luteus* | *L. brevis* | *L. lactic* | *P. vulgaris* |
|---|---|---|---|---|---|---|---|
| White | 3 | +ve | -ve | +ve | -ve | +ve | -ve |
| Black | 4 | +ve | +ve | +ve | -ve | +ve | -ve |
| L. brown | 3 | +ve | -ve | +ve | -ve | +ve | -ve |
| D. brown | 3 | +ve | +ve | -ve | +ve | -ve | -ve |
| L. red | 3 | +ve | +ve | -ve | -ve | +ve | -ve |
| D. red | 4 | +ve | -ve | +ve | -ve | +ve | +ve |
| L. blue | 2 | +ve | -ve | -ve | -ve | -ve | +ve |
| D. blue | 4 | +ve | +ve | +ve | -ve | +ve | -ve |
| L. yellow | 3 | -ve | +ve | +ve | -ve | +ve | -ve |
| D. yellow | 3 | +ve | -ve | +ve | -ve | -ve | +ve |
| L. orange | 3 | +ve | -ve | +ve | -ve | +ve | -ve |
| D. orange | 4 | +ve | +ve | +ve | -ve | +ve | -ve |
| L. purple | 3 | +ve | -ve | -ve | +ve | +ve | -ve |
| D. purple | 3 | +ve | -ve | -ve | +ve | +ve | -ve |
| L. green | 5 | +ve | +ve | +ve | +ve | +ve | -ve |
| D. green | 3 | -ve | +ve | +ve | -ve | +ve | -ve |
| Control | 2 | -ve | -ve | -ve | +ve | +ve | -ve |

**Key:** L- light; D- dark; +ve – present; -ve – absent.

**Table 3.** Distribution of the fungal isolates in the sample under varying colour light frequencies.

| Sample | No. | *A. niger* | *A. flavus* | *R. stolonifer* | *M. racemosus* | *F. oxysporium* |
|---|---|---|---|---|---|---|
| White | 4 | +ve | +ve | +ve | +ve | -ve |
| Black | 1 | +ve | -ve | -ve | -ve | -ve |
| L. brown | 3 | -ve | -ve | +ve | +ve | +ve |
| D. brown | 3 | +ve | +ve | -ve | +ve | -ve |
| L. red | 2 | -ve | -ve | +ve | -ve | +ve |
| D. red | 3 | -ve | -ve | +ve | +ve | +ve |
| L. blue | 3 | +ve | +ve | +ve | -ve | -ve |
| D. blue | 2 | +ve | +ve | -ve | -ve | -ve |
| L. yellow | 3 | +ve | +ve | +ve | -ve | -ve |
| D. yellow | 3 | +ve | +ve | +ve | -ve | -ve |
| L. orange | 2 | +ve | -ve | +ve | -ve | -ve |
| D. orange | 2 | +ve | +ve | -ve | -ve | -ve |
| L. purple | 2 | +ve | -ve | -ve | +ve | -ve |
| D. purple | 2 | +ve | -ve | -ve | +ve | -ve |
| L. green | 3 | +ve | +ve | -ve | +ve | -ve |
| D. green | 3 | +ve | +ve | +ve | -ve | -ve |
| Control | 2 | -ve | -ve | +ve | +ve | -ve |

**Key:** L – light; D – dark; +ve – present; -ve – absent.

(2.79%) had the highest % crude fat, fibre and ash respectively as compared with the control.

A total of 6 bacterial species were isolated from cassava during the period of drying. The bacterial isolates are *Staphylococcus aureus, Staphylococcus epidermidis, Micrococcus luteus, Lactobacillus lactic, Lactobacillus brevis* and *Proteus vulgaris* (Table 2). The results showed that there was no colour light frequency that reported the isolation of all 6 species of bacteria from cassava. Light green revealed the highest number of bacterial species while the control had the lowest. Only *P. vulgaris* was absent in light green, while the control revealed the presence of *L. brevis* and *L. lactic* only. In Figure 3, the total bacterial count for each of the colour light frequency revealed that light brown has the highest count while dark green has the lowest average count.

*A. niger, A. flavus, R. stolonifer, M. racemosus and F. oxysporium* are the fungi isolated during the drying of cassava. The results in Table 3 showed that there was no colour light frequency that reported the isolation of the 5

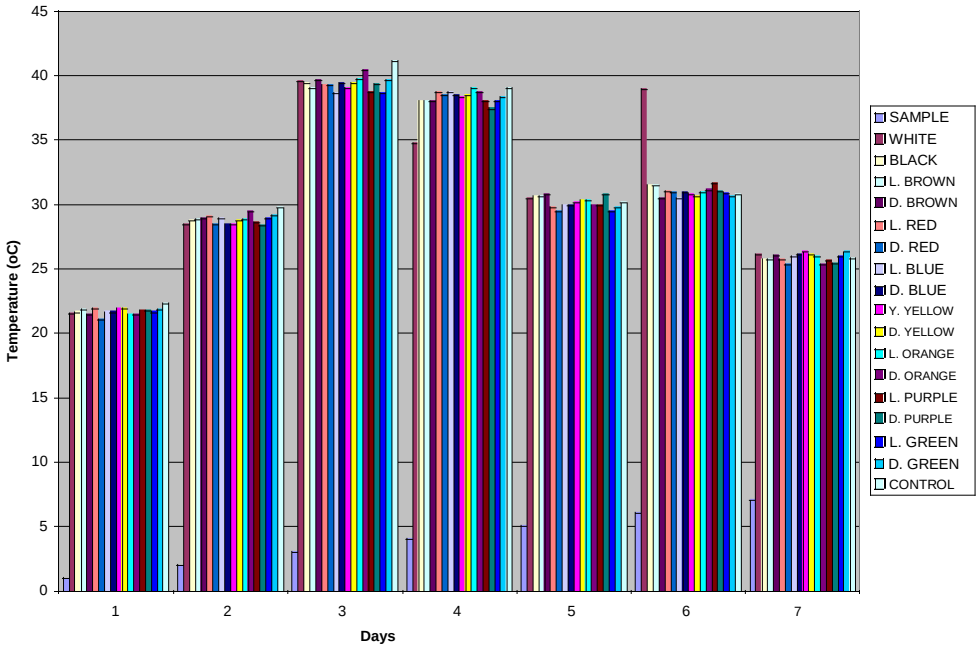


**Figure 1**. Average temperature (°C) of samples during the drying period. Values are means of three replicates determination (± SEM); Key: L- light; D- dark

fungal species from the cassava. White revealed the highest number of fungal species while the Black had the lowest. *F. oxysporium* was absent in the White, while the control revealed the presence of *R. stolonifer* and *M. racemosus* only.

## DISCUSSION

The findings from this study revealed that the analysis of variance proved that there was significant difference between the mean number of microorganisms in cassava samples and physico- chemical parameters like temperature, moisture content and proximate composition. In sun-dried cassava pieces, an inverse relationship seems to exist between cyanogens and microbial content (IITA, 1996).

Figure 1 showed the result of the mean temperature during the periods of drying; there was significant difference among varying colour frequencies compared with the control. However, there was no significant difference between the means of the same colour over the 7 days of drying ($p>0.05$). This may have accounted for the high distribution of bacterial isolates recorded during the period of drying possibly due to the temperature observed from each colour light frequencies which probably favours the growth of all the organisms isolated from cassava. This is in agreement with Ladan (1987), who reported that spoilage organisms could grow on cassava chips if the temperature is low and it is not dried properly.

As shown in Figure 2, the results of the moisture content revealed that there was significant difference among the various colour frequencies used in the drying process of cassava. Black colour recorded the highest moisture content (67.0%), while deep purple recorded the lowest (57.0%). This in agreement with Rowland (1993) who observed the same trend in the moisture content of cassava, yam and cocoyam.

The results from Table 1 revealed that there was significant difference among % crude protein, carbohydrate and vitamin C, while % crude ash, fat and fibre showed no significant difference. The result of % crude protein revealed significant difference between the varying colour frequencies as compared to the control ($p<0.05$). However, deep purple colour frequencies showed the highest crude protein composition (4.21%) compared to the control. Also, black and white showed the highest % carbohydrate (92.64%) and vitamin C (3.16%) contents respectively as compared with the control.

The results also revealed that deep orange, deep yellow and light purple had the highest % crude fat (3.03%), crude fibre (0.72%) and ash (2.79%) respectively as compared with the control.

The low protein content observed in cassava is in agreement with the work done by Nweke (1996) who also reported that cassava has low protein. The result of the % carbohydrate is however in contrast with that reported by Rowland (1983).

The result of the proximate composition was in agreement with Oyenuga (1968) and Rowland (1993) who both reported closer range of values for digestible true protein, fat, fibre, ash and carbohydrate.

The result of the vitamin C content of cassava is however in agreement with Kandler (1993) who also reported a similar trend in some cassava species. Since there is

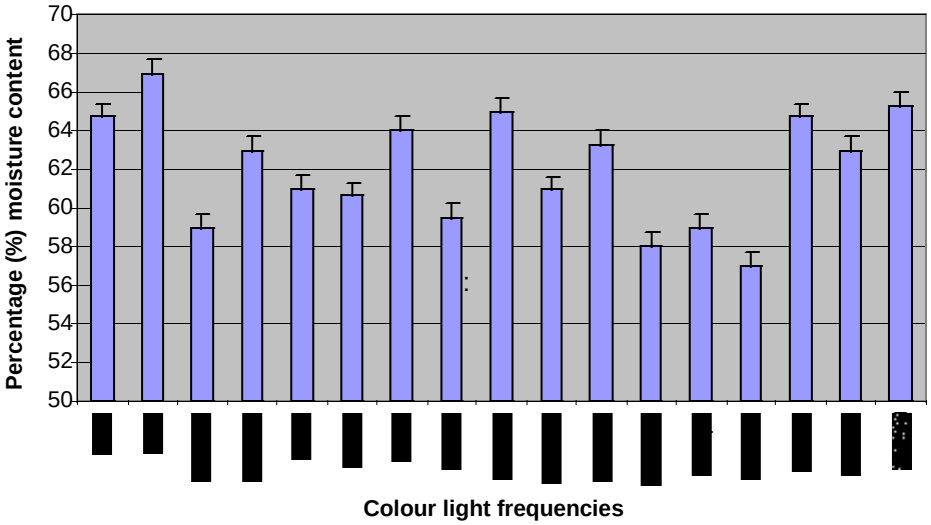


**Figure 2.** Percentage moisture content of sample under varying colour light frequencies. Values are mean of three replicates determination (± SEM).

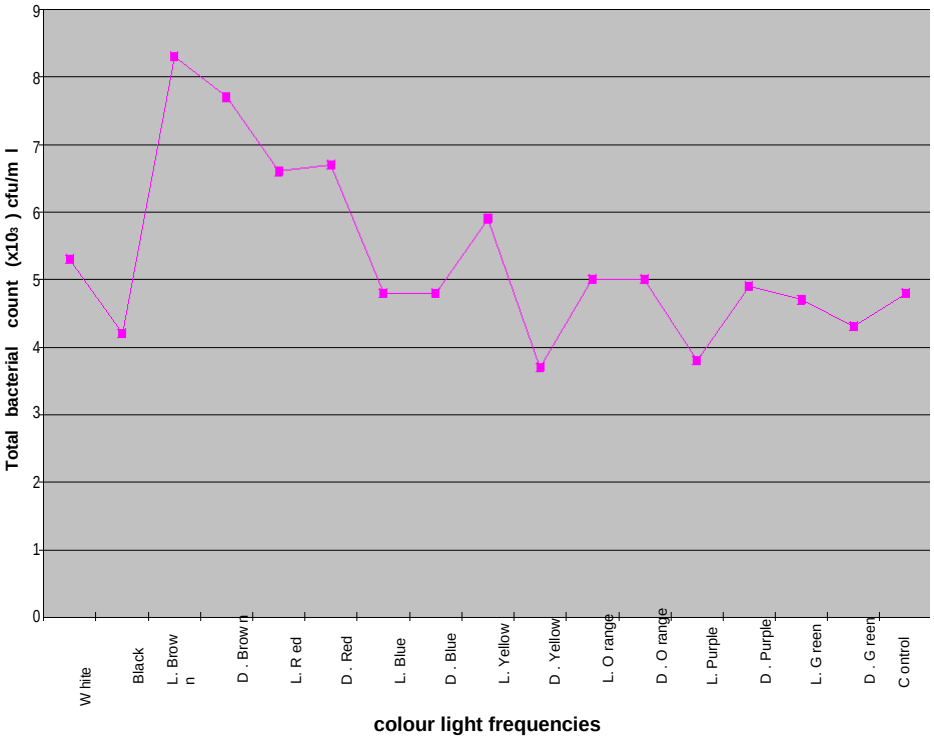


**Figure 3.** Total bacterial count from sample under varying colour light frequencies. Values are mean of three replicates determination (± SEM).

the availability of moisture and nutrients in cassava, the growth of microorganisms are greatly favoured in line with the supply of this nutrient (Table 2) . This can be verified from the decrease observed in the bacterial counts from samples which could possibly be due to the reduction in moisture content, as the cassava dries and the unavailability of water necessary for the growth of microorganisms.

The differences in bacterial composition and distribution among samples could also be adduced to the frequencies of light and variations in the amount of heat reaching the food. This is in agreement with the Food and Agriculture Organization of the United Nations (2004), that proposed that food dried in solar driers are better preserved and of good quality.

In Figure 3, the total bacterial count for each of the colour light frequency revealed that light brown has the high-

est counts while dark green has the lowest average count. The high presence of bacteria found in cassava samples is in agreement with Oyewole and Odunfa (1990) who reported that fermenting microorganisms are responsible for the spoilage observed in “lafun”, a product of dried cassava commonly found in the western region of Nigeria. However, majority of the fungi isolated from the drying of cassava are *A. niger, A. flavus, R. stolonifer, M. racemosus and F. oxysporium* (Table 3).

Of these fungi, *R. stolonifer* is a common bread mold, which causes much food spoilage. It grows on breads, fruits, vegetables and other food products (Pelczar et al., 1993) especially those with high carbohydrate content e.g. cassava and cassava products. *M. racemosus* occurs abundantly in soil, manure and on fruits, vegetables and on starchy foods. Some of the species of *Mucor* are responsible for food spoilage. Both *Rhizopus* and *Mucor* species are ubiquitous thermotolerant saprophytes and they form the leading pathogens in this group of fungi of the class zygomycetes (Jawetz et al., 2004).

## Conclusion

In relation to the control, there is no single light frequency that has the total desired advantages but if microbial contamination is to be minimized, light and dark purple are the preferred colour frequencies that can be used for the drying of cassava. This may be due to the fact that the purple (violet) has a frequency that is near to the ultraviolet frequency, which is injurious to microorganisms but with minimal destruction of nutrients.

### REFERENCES


AOAC (2000). Official methods of analysis of the Association of Official Analytical Chemists, 16th edition (William ed.) Virginia. pp. 834 - 841.

Bucchanans RE, Gibbons NE (1974). Bergeys manual of determinative bacteriology. Baltimore, Williams and Wilkin co 8th edition.

Cock JH (1985). Cassava: New potential crop. West view press, Boulder, co. p. 4

Fawole MO, Oso BA (2004).Biochemical Test. Laboratory manual of Microbiology, Spectrum books limited, Ibadan. pp.14-17

Food and Agriculture Organization of the United Nations (2004). The global cassava development Strategy and implementation plan. Proceeding of the validation forum on the cassava development Strategy. www.fao.org

IITA (1990). Cassava in Tropical Africa: a reference manual, IITA. In Nigeria Annual Report, IITA. Ibadan, Nigeria. p. 24

IITA (1996). Annual report: Plant Health Management Division, International Institute of Tropical Agriculture. Ibadan, Nigeria. p.10 IITA (1996). Improving Post Harvest System: Archival Report, Crop Improvement Division, and IITA. Ibadan, Nigeria. p. 121

Jawetz E, Melnik JI, Adelberg (2004). The Role of microorganisms in skin infections, Medical Microbiology, 23rd Edition, McGraw-Hill Company, Inc., U.S.A., p. 358.

Kandler O (1993). Carbohydrate Metabolism in Lactic acid bacteria Ant. V Leeuwenhoek, Williams and Wilkins Publishers, Baltimore U.S.A 49: 209-224.

Ladan MZ, Abubakar ML (1987). Effects of solar drying on the nutrient composition of tomato. Nigeria Renew Energy (1 and 2). pp.67-69

Michael JP, Pelczar JR, Krieng N (1993). Food spoilage. Microbiology, 5th edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, p. 221.

NSPRI (1983). Storing your produce cassava and Gari, Nigerian Stored Products and Research Institute. pp. 1-2, 13-14

Nweke F (1996). Cassava: A cash crop in Africa. COSCA working paper No 14 International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. p. 5

Nweke F (1994). Processing potential for cassava production growth in Sub-Saharan Africa, COSCA working paper number 11. Collaborative study of cassava in Africa, (IITA), Ibadan, Nigeria. p. 55.

O’Brien GM, Taylar AJ and Poulter NH (1991). Improved enzymic assay for cyanogens in fresh and processed cassava, Journal of the Science of Food and Agriculture, 56:277-289.

Onwveme IC (1978). The tropical tuber crops: yams, cassava, sweet potatoes, and cocoyams. Wiley and Sons publication, U.S.A. p.14

Oyenuga VA (1968). Nigeria’ food and feeding stuffs, Ibadan University Press. Ibadan, Nigeria, 1968. Edited by R.J Hillocks, J.M Thresh, and A.C Bellotti. CABI Publishing suite, New York, 2002. p. 135

Oyewole OB, Odunfa SA (1990). Microbiological studies on cassava fermentation for Lafun production. Food Microbiology. Ibadan University Press. Ibadan, Nigeria. 5: 125-133.

Rowland JRJ (1993). Dry land farming in Africa, Root crops. The Macmillan Press Ltd, London and Basing stoke. pp. 285-292.

Samson RA, Van Reenen-Hoekstra ES (1982). Introduction to food-borne fungi. 3rd edition. Centraal bureauvoor Schimmdoultur Baarn. pp. 2-89

Wikipedia, The Free Online Encyclopedia (2007). www. medlineplus.com.