SIZE REDUCTION OF CASSAVA CHIPS AND THE DRYING RATE

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Abstract
Effect of size reduction of cassava chips on the drying rate of cassava was investigated. The research covers physical ,chemical and dehydration operations. The sweet cassava variety (Boddeji Wata Uku) was used for the study which is prominent in Adamawa state, Nigeria and contains low level of cyanide content. Duplicate samples were used throughout the study and the values obtained were found to be significantly different from each other at ($p \leq 0.05$).The samples used has a constant surface area of 2.5mm by 2.5mm(6.25mm^2) with varying thicknesses of 3mm, 5mm, and 7mm were subjected o drying through the natural unconvectionalise temperature. It was observed that 3mm thickness had a higher rate of moisture loss of 0.64kgH_2Ohr, 5mm had 0.46kgH_2O/hr, while 7mm had the lowest of 0.40kgH_2O/hr at an average intensity of insulation of 40.5^{o}C,velocity of air 40m/s and relative humidity of 62%.The observed result was due to the increase in surface area and also the difference in the effective diffusitivities of the chips, however drying was achieved at the 7hrs for 3mm and 9hrs for both 5mm and 7mm .The final dried products were found to have a moisture content of 11.2%-12%.

Keywords: Size reduction, cassava chips, drying rate

Introduction

Cassava, a major staple food for may nations of tropical origin, America and Africa. A plant that account for a higher food calories per unit weight than yam. Cook and James (1985) reported that in Africa about 70% of cassava production is used as food. Cassava is playing a major role in an effort to alleviate the African food crisis (FIIRO, 2006) .

Onwueme(1978) stated that cassava is consumed only in its processed form due to its high hydro cyanide content(prussic acid) The processed form include, cassava chips, meal, flour and starch. In Latin America and the Caribbean, between 35 to 40% of the cassava production is used for human consumption and in Asia about 40% produced is for direct human consumption with much of the remainder expected as chips and pellets. In India baked roots are converted into small chips, flour and sago(roasted wet starch)

The socioeconomic importance of cassava provides a large percentage of the caloric requirements to the people of the Sub-Saharan and Africa. However, to a large degree cassava is considered as food for the lower and middle class. Though is of low protein content but high in good quality starch , contain approachable amount of vitamin C and minerals.70% of cassava production and over 50% cereal produced mostly in Nigeria are processed into different forms which includes gari, tapioca, abacha e. t. c

An industrial use of cassava has over the years been used in industries for different purposes. It is used directly as cooked starchy food, custard and other forms, as thinner, filler, binders, stabilizers, in bakery product, in confectionery, as animal feed, adhesive and particle board in industries like textile, pharmaceuticals ,foundry e.t.c The usage is mostly achieved by the conversion of cassava into starch for easy utilization..Recently Antekhai, et, al (2005) were able to produce biscuits from a composite flour (Cassava esculenta and Soybean Glycine maxima) with higher protein content as well as being nutritionally balanced. In addition, there has been an increase in the demand for cassava production in Nigeria due to Federal government policy to incorporate this indigenous food into the food system of the populace , for example cassava flour is now been incorporated into the wheat flour to make composite bread (I.I.T.A 2006)

Drying is a unit operation aimed at removing nearly all water present in foodstuff. Cassava is dried when water contained within them is removed into the surrounding air. This drying is associated with water present in cassava for prolonged shelf life of food. Water needs to be removed or reduced to a certain amount which hinders both biochemical and microbial activities Desroseir (1970) acknowledged that sun drying is an adequate method of food preservation under most conditions in developing economy , while dehydration denotes drying effected by artificial means; it is usually reserved for artificial drying methods employing a forced draft of conditioned air by mean of fans. The capacity of air for moisture removal depends on its humidity and its temperature.

Onayemi and Oluwakomi(1987)observed that drying cassava in form of fillets (1.0×1.0×5.0mm), proved to be more variable than the format of slices with 1.0mm and 2.5mm of thickness. Heldman, et, al (1981) also stated that food dehydration involves heat and mass transfer operation, heat transfer to the water in the cassava product. the water is vaporized and removed. Food drying is a unit operation for removing nearly all water present in a foodstuff. Foods are dried when the water contained within them is removed into the surrounding air. It must first move to the surface of the food and then be evaporated as water vapour. For effective drying , air should be hot ,dry and moving. The dryness of air often referred to as relative humidity (RH) .The lower the humidity the greater its capacity to hold extra vapour.. Humidity is affected by the temperature of the air. At higher temperature, the humidity is reduced and air can carry more water vapour

Cock and James (1985) stated that, wind is a fundamental factor during the process, which comprises two phases : The first phase involves loss of moisture quickly from the chips to 20% moisture content(MC) ,wind passing over the chips is more important than air temperature and relative humidity, under cloudy weather or even at night the first drying phase can be completed as long as there is sufficient air movement through the chips The second phase involves drying which is slower and needs a relative humidity if not higher than 65% to dry the chips to the required storage. Onayemi and Oluwakomi (1987) observed that a wet cassava chip exposed to heated air experiences progressive loss of weight due to removal of three forms of water: first is the free water , then the absorbed and finally the chemically bound water. Moreover the energy requirement for the removal of these form of water increase in that order with the free water requiring the least energy and the bound water requiring the highest energy for its removal. In general, the extent of moisture removal depend on temperature and humidity of the drying air.

When air is heated, it can contain more water vapor resulting in decrease in the relative humidity of the heated air and this may decrease by about 4%. Therefore, a product dries better in hotter air whereas when air cools off its relative humidity increases (which occurs during the night) thus making the product to dry less at a lower rate. For tubers it is best to dry products during the day while it is often better to cover the product at night to prevent dew formation and attraction of moisture coming up from the ground. Water being one of the most important constituents in food with varying amount depending on types of food.

The shelf life storage of any food depends on the amount of water contained in it. Thus water exists in three forms namely: - Free water or bound water, Absorbed or capillary water, Bound or monolayer water. When drying with circulation air, the main role of this air is to pick up water vapour on the surface of the product (cassava chips). Evaporating this water calls for heat, which can come either solely from the air above the products. The above statement was also observed by Yayock and Coubin (1988)). Theyobserved that air in its natural state contains moisture in the form of invisible vapour and the amount of moisture it contains can vary according to local climate, air movement in the atmosphere and clouds
Some mechanisms have been identified by Gorling (1956) as major ways of moisture movement from the interior of wet food. This include: liquid movement caused by capillary forces. Diffusion of liquid caused by differences in concentration, surface diffusion in liquid layers absorbed at solid interphase as well as vapour diffusion in air filled pores caused by differential or partial pressure gradient. Some of the phenomena identified during drying of food material include: movement of soluble solids in consonance with the migration water, shrinkage of the tissue (vegetable) ,case hardening , loss of volatile components as well as loss of volatile components. As drying progresses there is a flow of water to the surface as it carries soluble components although the movement of this soluble component is hindered by cell walls. However as the surface dries out a concentration gradient is set up between the water and the wet centre. Gorling(1956) suggested that migration of soluble solids is in the opposite direction towards the centre of the piece of food and as the surface dries up the center becomes wet.

A typical drying curve for a wet material showed that drying involves distinct stages which suggest changes in the mechanism of moisture removal. The stages are divided into three namely; settling down period, constant rate period and falling rate period. The settling down period or the first phase is usually short (in which drying increases) , to non existence , and it corresponds to the rise in temperature of the product until it reaches an equilibrium, when the product receives as much heat from the air as it needs to give to the water to vaporize. Constant rate period corresponds to the period of evaporation of the free water on the surface of the product, which is permanently renewed by the moisture coming from inside of the product while falling rate (decrease in drying velocity) corresponds to the evaporation of bound water.

Cassava is gradually making its way up in the world market due to its high demand but this is hindered by the low production of cassava. The Federal government of Nigeria attempted to boost the production of cassava and encourage its economy through the export of cassava. Now, many large populations in Nigeria live on farming of cassava as a means of livelihood both within the urban and rural area. Unfortunately prussic acid is a major problem in the consumption of cassava which in its minute quantity can kill an adult, although many workers have reported a significant reduction of cyanide during processing of cassava into some traditional African foods(Mahungu , et, al 1987). Most cassava products rely on drying before utilization .The objective of dehydration of cassava includes among others reduction of water activity to a level where no microbiological activity can occur and chemical and biochemical reaction rates are minimized at moisture content below 10%.reduction in product volume and hence in transport and storage costs and in addition reduction in moisture content results in increased shelf storage life and preservation of quality characteristics such as flavor and nutritive value, often achieved at moisture content below 5%.

Cassava processing is required on a large scale; attempt has to be made to look for the safe moisture content, minimal thickness to facilitate drying and the thickness that can promote longer storage without spoilage due to microbial interaction.

Therefore this research was carried out to study the effect of reduction of cassava chips on the drying rate of cassava, to recommend ideal moisture content for storage and to provide data for the fabrication of drying equipment.

Materials and method

Source of raw materials

Cassava, the major raw material used for this research was obtained from Girei main market Adamawa state . The variety used is the sweet cassava called the "Bodeji wata uku". A variety of Manihot palmate. All necessary equipments was obtained from the laboratory of Food science and Technology Department , Federal University of Technology Yola.

Research methodology

Processing of Cassava chips

The processing of cassava chips followed the traditional method described by Akingbala et al (1991). Cassava roots were washed and allowed to drain or dry. The fresh cassava roots were peeled and then chipped using knife and micrometer screw gauge for measuring the adequate size 2.5mm by 2.5mm with varying thicknesses. The weight was taken, dried and reweighed every 15minutes until negligible weight difference was obtained. The processing of cassava chips follow the processing steps below (fig:1)

Cassava tuber
↓
Washing
↓
Drying
↓
Slicing / cutting
↓
Drying
↓
Packaging (nylon seal)
↓
Cassava chips

Figure 1: Processing of cassava chip

A preliminary trial experiment was conducted to carry out the drying at lower and higher drying temperature and air velocity to ascertain the best drying temperature and air velocity over the period of 9hours of drying time

Chemical analysis

Proximate composition

The proximate composition of the cassava chip was determined as follows .The moisture content and crude fat were determined according to Pearson(1976)while Ash and protein were determined using AOAC(1990) while the carbohydrate was estimated by difference.

Statistical analysis

The data's obtained for the chemical analysis and weight loss for every drying hour for different chips thicknesses were subjected to statistical analysis using standard procedures of analysis of variance and multiple range testing of the mean difference at 5% significant level (Amerine, Pangborn,& Roessler, 1965; Snedecor &Cochran, !967; IFT, 1981)

Results and discussion

Table 1: shows the result of chemical analysis of cassava chips at different thicknesses. The result showed that the values were found to be significantly different at ($p \leq 0.05$) from each other. Protein content in the sample ranged from 1.90-2.50. Although the raw sample had the lowest protein content , however, the fat content of samples ranged from 0.09-0.12 with the raw sample having the highest value and the sample with thickness(5mm) with the lowest value. The ash content rightly follow a similar trend with the thickness (5mm) having the lowest ash content while the 3mm thickness has the highest value.

The moisture content of the sample ranged from 11.20-12% moisture content with the raw sample having the highest value followed by the 3mm sliced sample while the 7mm sliced sample had the lowest among the sliced samples. The above result for the dried samples of thicknesses 3mm, 5mm, and 7mm agree with that values obtained by Oyenuga (1968). The moisture content slightly differ, this can be due to loss of moisture during storage and the he harvest.

Visual examination was carried out on the samples. It showed that there was no color change in all the samples examined at moisture content of (11.2-12%) below the safe moisture content of 13% reported by Onayemi and Oluwakomi (1987).There is adequacy in drying at the various thicknesses investigated. This shows that at the level of the thickness (3mm-7mm), the drying does not support the growth of mould and hence there was no observed colour change

Table 1: Chemical Analysis of cassava chips

Parameter	Raw cassava	3mm	5mm	7mm
Protein (%)	1.90±0.0		2.40±0.0	2.5±0.0
2.20±0.0				
Fat(%)	0.12±0.0		0.10±0.0	0.09±0.0
0.10±0.0				
Ash(%)	1.10±0.0		1.11±0.0	1.00±0.0
1.12±0.0				
Moisture(%)	65.00±0.0		12.00±0.0	11.20±0.0
11.20±0.0				

Drying temperature: 50^0C, air velocity 40.4m/s. relative humidity of 62% and drying time 9hours.

Table 2: shows the result of weight of cassava chips obtained for every drying hour and the weights were reported on hourly basis. Size of chips taken were at varying thicknesses of 3mm, 5mm and 7mm,with a standard size of 2.5mm by 2.5mm giving an area of $6.25mm^2$. The result showed that during drying of the chips, there was reduction in the weight of he chips, although the reduction in weight is not at a regular time interval. This could be attributed to the wind velocity which affects the drying rate and moisture removal. This statement agrees with Yayock and Coubin(1988).

They reported that when drying with air , the main role of the air is to pick up the moisture from the surface of the product and this is further affected by its speed and amount of moisture it originally contains. Yayock and Coubin(1988) further reported that air serves as a medium in picking up moisture from the surface of cassava chip, hence, the free moisture is the one involve in the drying process. Drying becomes apparently difficult if all the free water in cassava have been removed. Because the moisture left in the product remains bound in it by hydration which has to be broken.

It could be observed that there was a decrease in the free moisture contained in the cassava chips for the 3mm, 5mm, and 7mm respectively over the 8 to 10 hour s drying period. It was also observed that the central moisture loss for the 3mm sample remains the highest, (0.64kg) at a period of 1hr followed by(0.46kg) for 5mm and (0.40kg) for 7mm respectively. The moisture loss for the 3mm was negligible after 7hrs whereas for 5mm and 7mm it took 9hours. This is because the 5mm attain the constant period over a short period of 2hours of drying followed by the falling rate period for the remaining 5hours(Table 2) whereas 5mm thickness had had a constant rate period for a period of 4hours followed by the falling rate period until after 9hours.

The similar trend was also observed for 7mm at which the constant rate period followed by the falling rate period. The observed difference in the two cases can be attributed to a particular size which exposes large surface area and therefore, the rate of moisture loss. This agrees with the finding of Bruno and Romeo(1977) which they examined during the drying behavior of different sizes of fillet (1×1×5.0mm), 1.0mm thick, they found that the fillets (1×1×5.0mm), 1.0mm thick and 2.5mmthick they found that the fillet was more viable. The drying could not be extended for more than 7hours for 3mm thickness and 9hours for 5mm and 7mm respectively to avoid case hardening as reported by Gordling(1956) . He reported that high temperature and length of exposure may result in case hardening and undesirable changes in taste which occurs at the initial drying and constant rate period of drying

Table 2 Weight of Cassava Chips for every Drying Hour

	Weight of chips(gm)		
Time(hr)	3mm thick	5mm thick	7mm thick
0	3.58±0.01	5.39 ± 0.01	6.17±0.02
1	2.73±0.02	4.48±0.00	5.26±0.01
2	2.27±0.02	3.93±0.01	4.73±0.00
3	1.88±0.01	3.45±0.00	4.17±0.00
4	1.65±0.00	3.03±0.02	4.71±0.01
5	1.57±0.01	2.76 ± 0.00	3.35±0.01
6	1.55±0.01	2.56±0.01	3.08±0.00
7	1.54±0.00	2.37±0.00	3.08±0.00
8	-	2.36±0.01	2.69±0.01
9	-	2.35±0.00	2.67±0.00

Drying temperature: 50^0C, air velocity 40.4m/s. relative humidity of 62% and drying time 9hours

Conclusion

The quality of cassava chips obtained in this study revealed that the quality is influenced by several variables which includes air velocity , temperatures of the drying air ,size of chips , the surface area of the chip and relative humidity of the atmosphere are very important in achieving results during the drying process. Simulation of the traditional process of drying whereby no consideration of the thickness and the size of the chips are taken will result in loss of product quality due to discoloration caused by this removal of moisture from the surface of the cassava chips thus aid the proliferation of microbial and biochemical activities within the cassava chips.

The result from the study showed that at smaller sizes and thicknesses of cassava chips, drying of 3mm chips dry faster over a period of 7hours when compared to 5mm and 7mm of 9hours drying. The next important thing is the air velocity which aids the removal of moisture. Small thicknesses of the chip remove more moisture at a very short time because moisture travels a shorter distance by capillary action from within to the surface of the chips with higher thickness. This is why the 3mm thickness dries faster because of exposure of large surface area. Higher moisture is removed at a higher temperature usually around 50-70^{o}C with the other variables under control, however, higher temperatures may result in undesirable changes to the product due to changes in biochemical reactions .The law of Q_{10} states that for every 10^{o}C change (increase) in temperature the reaction of biochemical process is doubled with the products but lower than 50^{o}C may promote the proliferation of microbial activities.

This result showed that within the temperature of 50^{o}C, air velocity of 40m/s and relative humidity of 62% at which this study was carried out, 3mm thickness will achieve a drying time of 7hours.

It can therefore be concluded that equipment can be fabricated to accommodate for the size reduction for cassava chips at 3mm size with the prevailing conditions at which this study was carried out: temperature 50-70^{o} C, air velocity of 40m/s and relative humidity of 62%.The data becomes more useful in the construction of an equipment that could facilitate quick rate of drying of cassava. This is necessary as it is required as a basis in the production of many cassava processing industries in proving efficiency and time for utilizing cassava in producing the finished product.

References

Ajala A.S Adejuyitan J.A , Babarinde G.O Effect of different drying methods on physical properties of cassava flour .Proceecindings of 33rd Annual conference of Nigerian Institute of food science and Technology. pp 151-151.

Akingbala V. O and Oguntimehin G.I .B(1991) Effects of processing methods on quality and acceptability of fufu from low cyanide cassava. *Journal of Science and Agric*. Vol 53 pp151-154

Antekhai W.E and Ozakhome M. (2005) . Production of a composite flour (Casava manihot esculenta and soybean Gycine maxima) for the production of nutritionally balanced biscuits. *Internatonal journal of Food and Agricultural Researc*h vol. 2 No 1& 2 pp 52-56

AOAC(1990) *Official method of analysis(15th ed)* , Washington, D.C Association of Analytical chemistry pp.1546

Desroseir N.W (1970) *The Technology of food preservation* Westport Connecticut: Avi Publishers

FIIRO(2006). *Cassava production, processing and utilization in Nigeria* Lagos: FIIRO.

Gorling, P. .(1956) *Physical phenomenon during the drying steps in fundamental aspect of foodstuff,* New York: Macmillan.

Heldman and Singh R.P (1981) *Food process engineering* 2nd edition, Westport Connecticut: AVI Pub.

I.I.T.A (2006) Bulletin p.1

IFT(1981), Sensory evaluation guide for testing food and beverage product *Food Technology,* 35, 50-59

Mahungu N. M, Yamaguchi Y. Almazan A.M, Hahn S. K(1987). Reduction of cyanide during processing of cassava ino some traditional African foods. *Journal of Food and Agric* vol 1 pp. 11-15.

Onayemi and Oluwakomi (1987) Moisture equilibra of some dehydrated cassava and yam products *Journal of process engineering* vol. 9 pp.191-200.

Onwueme(1978) The tropical crops. New York : Publishers pp.234.

Oyenuga (1968) *Nigerian food and feeding stuff* Ibadan: Ibadan University Press.

Pearson(1976). *The Chemical Analysis of foods*. 7th ed. London: Churchill Livingston pp 324

Snedecor G.W. and Cochran, W. G.(1967). *Statistical methods* (6th ed) Ames, 1A Iowa University Press.

Yayock and Coubin(1988) *Crop science and product in warm climate* London: Macmilllan publishers limited