

Effects of Storage Period and Moisture Content on Vacuum-Sealed Cassava Mash

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Page | 4198

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ABSTRACT

High-quality cassava flour and starch processing are hindered by distance between farms and flash dryers and the deterioration of cassava root after 24 hours of harvest. A vacuum sealer was used to investigate the effect of storage parameters on vacuum sealed cassava mash. The input variables were 5 levels of storage period and 3 levels of moisture contents. The output parameters were pH, total titratable acid, free cyanide and total cyanide. The Analysis of Variance revealed that both factors and their interaction were significant at 5% significance level. The vacuum sealed cassava mash was stored for 10 weeks and it was found that between 0 – 4 weeks there were no marked variation in the properties of pH, total titratable acid, free cyanide and total cyanide. It was observed that after the fourth week of storage pH increased as the moisture content and storage period increased. However, the total titratable acid, free cyanide and total cyanide decreased as the moisture content and storage period increased. This study revealed that cassava root could be harvested, processed into mash within 12 hours and stored in a vacuum sealed polythene bag and its quality will still be intact within four weeks. Hence, vacuum sealed cassava mash has a shelf-life of four weeks under ambient conditions.

Keywords: Cassava mash, storage, vacuum sealing and shelf-life

Introduction

Cassava (*Manihot esculenta* Crantz) is a woody food plant from the Euphorbiaceae family (Maziya-Dixon *et al.*, 2007). Bye-products of cassava are high carbohydrates and energy content (El-Sharkawy, 2004). Cassava is utilized as food for man and raw material for industries (FAO, 2012). Increase in population, urbanization, and migration has constantly influenced the prominent usage of cassava and its industrialization over the past years, creating awareness about the vast usefulness of the crop (Uchekukwu-Agua *et al.*,

2015). Over the past 20-30 years, Cassava as a major foodstuff of rural communities, has gained significant recognition both in developing and developed nations due to the frequent exportation of the crop. It has aided socio-economic development within rural sectors by improving income for local settlers, through the generation of employment opportunities. (Uchekukwu-Agua *et al.*, 2015). Iyer *et al.*, 2010 reported that cassava could be grown all year round in diverse soil types. Cassava also is a sort of insurance against hunger

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as it could be left in the ground for long before being uprooted (El-Sharkawy, 2004).

Cassava roots, depending on its breed and storage conditions, when stored just like other agro products are sensitive to chilling injury, internal breakdown, drying, decay, loss edibility and failure to germinate (Iyer *et al.*, 2010). Cassava roots generally degenerate fast after harvest which takes place in two stages: Physiological or primary deterioration and Microbial or secondary deterioration. The physiological changes of cassava root start 24 hours after harvest with a blue-black discoloration which will be visible to the eyes after 24 hours, at ambient storage temperature (Iyer *et al.*, 2010). The colour changes then fermentation occurs thereby causing an offensive odour which indicates complete rotting (Buschmann *et al.*, 2000). This physiological deterioration is caused by its high moisture content (60 to 75 %, wet basis) and high respiration rate ($\approx 23 \mu\text{L CO}_2/\text{kg/h}$ at 25°C) (Salcedo *et al.*, 2010). The microbial deterioration of cassava root leads to fermentation and decaying of the root tissue which occurs 4–5 days shortly after the physiological deterioration from the wounded points (Buschmann *et al.*, 2000). Physical damage such as wounds, cuts, and bruises serve as focal points for microorganisms and lead to microbial deterioration (Falade and Akingbala, 2010). Cassava root cannot be left in the soil for a too long because longer the cassava root stays in the soil after maturity the more it becomes fibrous and its starch content will be affected.

However, it has been observed that when cassava root is processed into different forms, it gives it a stable shelf life and improved quality. Cassava root could be used to make either unfermented or fermented foods or drinks. Vacuum packaging is achieved by removal of air from a polythene bag containing food material with a vacuum pump and then sealing the bag. By getting rid of air in the bag, activities of the micro-organisms that may deteriorate the quality of the food material is drastically reduced. Thus, the quality of the food is

sustained and shelf-life is increased (Sanni, 1996). Air-tight polythene bag was discovered to be the best material for storing gari (granular product from cassava) (Adebola *et al.* 2014). Likewise, storing gari in bags made from polypropylene was claimed to retain its desired qualities for five months (Awoyale *et al.*, 2021).

Cassava can be processed into various by products which are done domestically or industrially. The usage of the cassava by-products determines its processing methods. Most of these are processed from the cassava mash (Oduah *et al.*, 2015). Hence there is need to peel, grate and pulverise to cassava mash since most of the by-products of cassava are processed from its mash. The problem with the cassava mash is its storage and maintaining its qualities especially when processing into high quality cassava flour and starch. Processing of high-quality cassava flour and starch, the cassava root must be processed within 12 hours of harvest (IITA, 2010). Most of the research done on cassava mash was based on fermentation of the mash for a certain duration of time and investigating their qualities. The qualities are based on the changes in the values of the pH, total titratable acid and cyanide level. Ogueke *et al.*, (2013) studied the quality characteristics of cassava mash as affected by fermentation variables for 96 hours where it was reported that there was an increase in pH values as the total titratable acid increased. Processing of high-quality cassava flour and starch from cassava root are hindered by the deterioration of cassava root after 24 hours of harvest, long distance between cassava supply and processing equipment (flash dryer). Likewise, the flash dryer requires a certain minimum quantity for energy efficient operation (Adebowale *et al.*, 2011). Hence there is a need to devise a means of preserving the quality of cassava mash which could be easily done within 12 hours of harvest until it reaches the required quantity and location of the flash dryer. Therefore, the objective of this research was to investigate the effects of storage time and moisture content on the storability of vacuum sealed cassava mash.

Materials and Methods

Description of Machine Parts

The vacuum sealer fabricated for this research comprised of a rectangular casing that housed the vacuum pump connected to a suction tube which extracted air out of the cassava mash. The vacuum pump was a refrigerator compressor (Danfoss, 160 W, 230 V, 0.9 A) which was contained a box on the vacuum sealer. The suction end of the compressor was connected to a tube that was cut into a triangular shape of 185 mm x 150 mm. This triangular shaped tube was fitted into the polythene bags of cassava mash for the purpose of extracting air from it. The sealing chamber was attached below the box containing the compressor. It consisted of the heater bar and the pressure bar. An impulse sealer (PFS – 300, 220V, 400 W, 0.2 – 1.5 s) was used to seal the 250-gauge polythene bags. The heater bar consisted of the heating element and Teflon for heating while the pressure bar pressed the bag against the heater bar for good quality sealing. A foot pedal was attached to the basement of the structure which actuated the pressure bar for the sealing operation. The fabricated vacuum sealer is shown in figure 1.

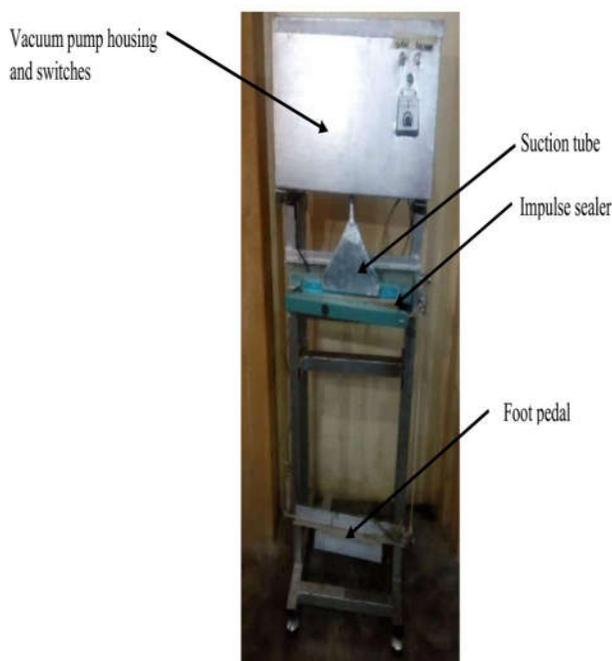


Figure 1: The Fabricated Vacuum Sealer

Principle of operation

The improvised vacuum sealer worked on the principle of sucking internal air from the bag and then sealing immediately. The essence of removing air is to prevent chemical reactions triggered by oxygen that could cause spoilage and bacteria build up. Cassava mash at the desired moisture contents by weight was packed into 250-gauge polythene bags. The vacuum pump of the vacuum sealer was switched on and each sample bag was placed between the heater bar and the pressure bar. The suction tube was inserted in the bag and the bag was held firmly to it with the aid of pegs. Enough space was left to accommodate the suction tube above the heater bar. A distance of 2.54 cm between the content of the polythene bag and the suction tube was left. The suction process was allowed to continue until the polythene bag was sticking firmly to the cassava mash. At this point, the heater bar of the sealer was switched on. The pressure bar of the sealer was depressed in order to seal the polythene bag. The sealing process was pre-set to last for three seconds and it automatically turns off after three seconds.

Sample Preparation

The cassava roots variety TME 419 which was 11 months old at the time of harvest was obtained from National Centre for Agricultural Mechanization (NCAM), Kwara State. The cassava tubers were, peeled, washed and then milled into mash immediately. Extra care was taken to ensure the whole process was accomplished within 9 hours of harvest. The procedure followed was in accordance to IITA (2010). Samples of cassava mash were weighed with weighing scale (Model CL201) and poured into polypropylene woven sack (25 cm by 15 cm). Each cassava mash sample were then dewatered for two days with a cassava dewatering gantry. The gantry was made from wooden frame (24 cm x 39 cm x 27 cm), a flat wood (20 cm by 35 cm) and hydraulic jack (5 tons). The average mass of 10 samples of dewatered cassava mash was found to be 120g and the moisture content were

analysed using moisture analyser (N LSC-50). The average moisture content obtained was 42.89 % (wb). Equation (1) which was given by (Sacilik *et al.*, 2003) was then used to obtain the quantity of water that should have been left to achieve some selected moisture content levels. The quantities of cassava water obtained from using equation (1) was then added to the samples according to the desired moisture content. The samples were left for 30 minutes to allow the water to permeate the cassava mash and then weighed. This procedure was repeated for each sample of cassava mash used in this research.

$$Q_w = W_i \frac{M_f - M_i}{100 - M_f} \quad (1)$$

Where

Q_w is quantity of cassava water added

W_i is initial weight of the sample (kg)

M_f is final moisture content (%) wb

M_i is initial moisture content (%) wb

Experimental Design

A 3 x 5 factorial experiment was used for this study. The factors used were three levels of moisture content of the cassava mash (M) and five levels of storage periods (SP). The moisture levels of the cassava investigated were 45% (M_1), 55% (M_2) and 65% (M_3), the storage periods were 2weeks (SP_1), 4 weeks (SP_2), 6 weeks (SP_3), 8 weeks (SP_4) and 10weeks (SP_5). The moisture content of the cassava at 45%, 55%, and 65% were achieved by adding 4.8 g, 32.5 g and 76.1 g of cassava water respectively. The independent variables were the moisture content and storage periods. The dependent variables were pH, Total titratable acid, free cyanide, and total cyanide. Each treatment combination was replicated three times. The total experimental runs were 45. Storage was done

carefully by packaging, labelling and storing the samples in a thoroughly cleaned ambient environment. The average ambient room temperature was 28.5°C (53.38 %, relative humidity) monitored by a thermo-hygrometer (Model TA298). Variations in the quality of vacuum-sealed cassava mash during the storage period was investigated. The temperature of the storage environment was constantly monitored and recorded before physiochemical analyses which were carried out weekly in the Laboratory of Chemistry Department, University of Ilorin. The collected samples were taken to the laboratory and tested for pH, Total Titratable Acid, Free Cyanide and Total Cyanide. This experiment continued for ten weeks. However only the data for 2nd, 4th, 6th, 8th, and 10th weeks were used for statistical analysis. The procedure for the preparation of the samples is illustrated in the flow chart in figure 2. Data obtained from the experiments were put through analysis of variance (ANOVA) using SPSS version 25 to investigate the level of significance of each factor and their interaction. Furthermore, New Duncan Multiple Range Test was used to compare the significant difference between the levels of each factor.

Results and Discussion

The laboratory analysis for this research were carried out on weekly basis after storage of the vacuum-sealed cassava mash. The results of the variations in the pH value, total titratable acid, free cyanide and total cyanide with storage period at moisture content (45%, 55% and 65%) at ambient environmental condition are presented as follows.

The summary of the Analyses of Variance for pH value, Total titratable Acid, Free Cyanide Content and Total Cyanide Content is shown in Table 1. It was observed that both factors and their interaction were significant at 5% level of significance.

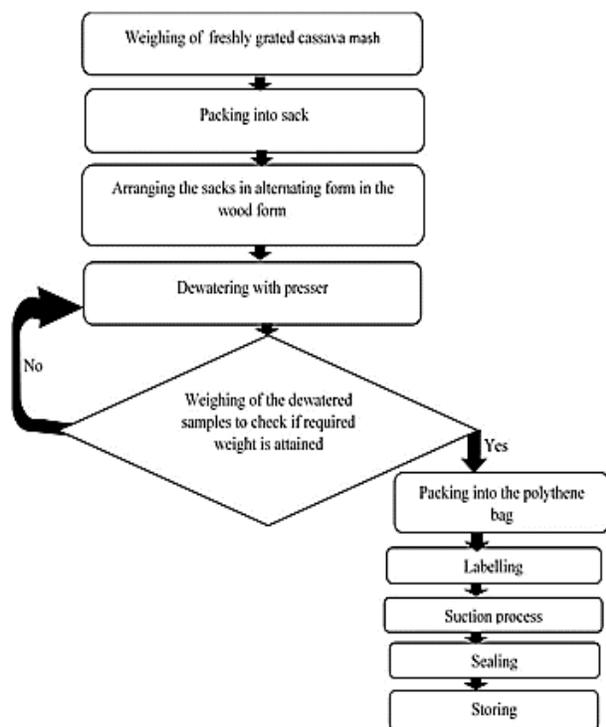


Figure 2: Preparation of samples for the experiment

Table 1: Summary of Analyses of Variance: F-values for all Measured parameters

Source	pH value	Total titratable Acid	Free Cyanide Content	Total Cyanide Content
M	0.000*	0.000*	0.000*	0.000*
SP	0.000*	0.000*	0.000*	0.000*
M * SP	0.000*	0.000*	0.000*	0.000*

* Significant at P < 0.05; M = moisture content; SP = storage period

Effect of Storage period on the pH Value at different Moisture content

From figure 3, there was no marked variation in the pH value from 0 – 4 weeks. However, the pH value increased as the storage period and moisture content increased. Figure 3 also shows that the highest pH value was observed at 55 % after 10

weeks storage period and the least pH values at 65% moisture content after 4 weeks storage period. This is in line with the report of Akingbala *et al.* (2007) that claimed that decreasing the initial moisture level of mash below 60 % increased the pH value. It was observed that pH value started to change after 4weeks of storage. This shows that there is variation in the value of pH during storage period with respect to moisture level.

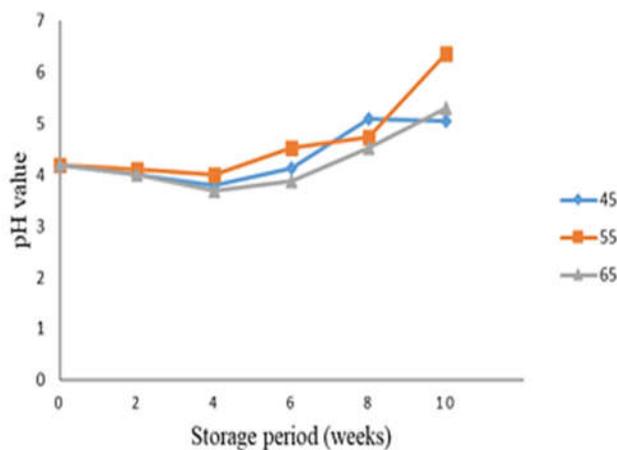


Figure 3: Effect of Moisture Content and Storage Period on pH Value

Effect of Storage period on Total Titratable Acid at different Moisture content

It could be observed from figure 4 that total titratable acid value decreased as the storage period and moisture content increased. The total titratable acid values in the figure reveals that the maximum total titratable acid value at 45 % moisture content of 4 weeks storage period while the minimum total titratable acid value was observed with 55% moisture content at 10 weeks of storage. This may be due to the fact that the alkalinity of the mash as this conforms to the earlier results on pH. This is also consistent with report of Awe and Nnadoze (2015). During storage of cassava mash, according to Oduah *et al.* (2015) fermentation has been reported to lower the pH values which lead to increase in titratable acid. However, in this study the pH value increased while the titratable acidity decreased. This indicates that poor or no

fermentation occurs hence this can be attributed to the vacuum sealing as reported by Awe and Nnadoze (2015) which reduces the activities of bacteria and yeasts.

Page | 4203

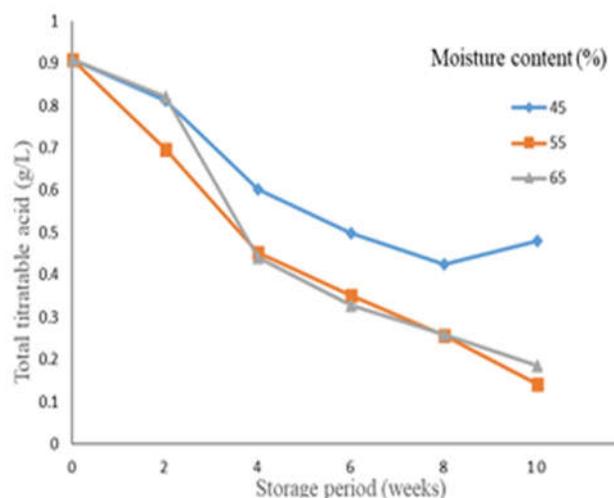


Figure 4: Effect of Moisture Content and Storage Period on Total Titratable

Effect of Storage period on Free Cyanide at different Moisture content

The free cyanide content observed in figure 5 decreased as the storage period and moisture content increased. It shows that at 55 % moisture content after 2 weeks storage period, the maximum free cyanide content was observed while the minimum free cyanide content was observed at 55% moisture content after 10 weeks of storage. This could be explained by the reduction of moisture content below the initial moisture content as reported by Tetchi *et al.* (2012). The pressing of the mash may have removed water soluble free cyanide after hydrolysis of the glucosides which leads to reduction in free cyanide content. Also, the reduction in free cyanide content is in accordance with the report of Ogueke *et al.* (2013) and Oduah *et al.* (2015) that as the storage period increases the free cyanide reduce.

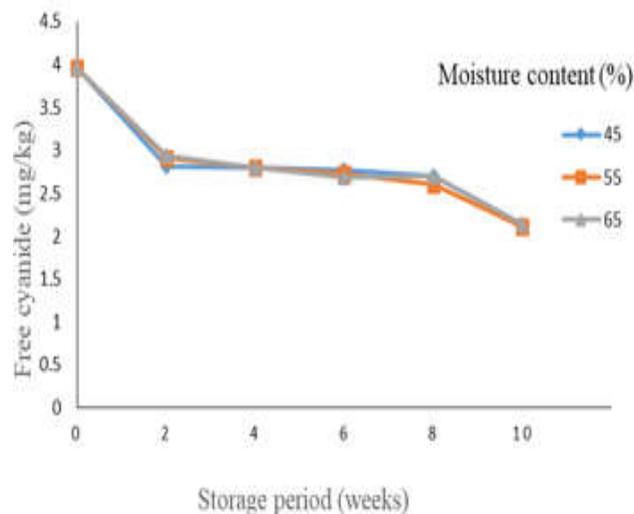


Figure 5: Effect of Moisture Content and Storage Period on Free Cyanide Content

Effect of Storage period on Total Cyanide at different Moisture content

The total cyanide content observed in figure 6 decreased steadily as the storage period and moisture content increased. The figure indicates highest total cyanide content (28.9 mg/kg) at all moisture contents while the least total cyanide content (19.03 mg/kg) was at 55 % moisture content of 10 weeks storage period. According to Oduah *et al.* (2015), 95% of the initial linamarin hydrolysis occur during milling hence depicting that milling is an important step in cyanide glycoside hydrolysis. Tetchi *et al.* (2012) also reported that fermentation causes removal of endogenous cyanide in cassava root after 48 hours. This shows that in this study the vacuum sealing has effect on the fermentation process if not the cyanide content will have reduced drastically within the storage period.

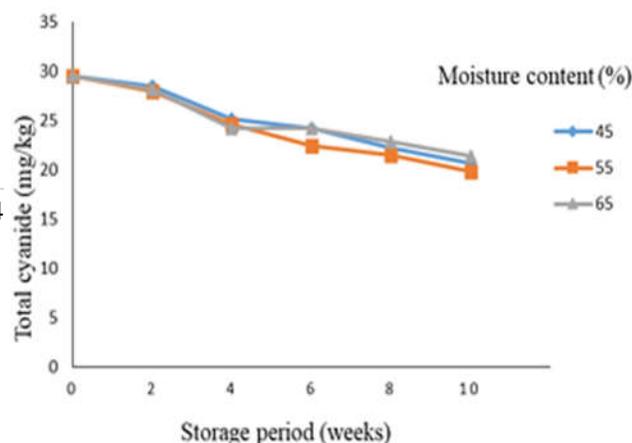


Figure 6: Effect of Moisture Content and Storage Period on Total Cyanide Content

Conclusions

The vacuum sealer was improvised as a test rig to investigate the storability of cassava mash. The vacuum sealer was used to study the effect of moisture content and storage period on pH, total titratable acid, free cyanide and total cyanide of the stored vacuum-sealed cassava mash. It was found from the Analysis of Variance Test that the moisture content and storage period were significant at 5% level of significance. The vacuum sealed cassava mash was stored for 10 weeks and it was found that between 0 – 4 weeks there were no marked variation in the properties of pH, total titratable acid, free cyanide and total cyanide. It was observed that after the 4th week of storage, pH increased as the moisture content and storage period increased. However, after the 4th week of storage, the total titratable acid, free cyanide and total cyanide decreased as the moisture content and storage period increased. It was observed from this study that harvested cassava could be processed into mash within 12 hours and stored in a vacuum sealed polythene bag without loss in its quality within 4 weeks.

Conflict of Interest

The authors hereby state that there is no existing conflict of interest.

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