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Storage Stability of *Pupuru* Flour (A Cassava Product) at Room Temperature

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Research Article

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ABSTRACT

Aims: The knowledge of water sorption Isotherm gives information about water activity of foods; to investigate chemical reactions during drying and storage. This study therefore, was to determine the sorption properties of *pupuru* flour during storage at ambient temperature.
Study Design: Research study.
Place and Duration of Study: The study was carried out in the Food Processing Laboratory of Food Science and Technology Department of Federal University of Technology, Akure, between April 2009 and December 2009.
Methodology: Adsorption characteristics of *pupuru* flour, a fermented cassava product, were determined at room temperature of 27°C using the static gravimetric procedure. Samples were equilibrated in desiccators containing tetraoxosulphate (VI) solution of known water activity (0.1-0.6). The data obtained were fitted to four moisture sorption models, namely Henderson, Chung Pfost, Oswin and Caurie for their predictive capabilities.
Results: The coefficients of determination varied from 0.881- 0.993. Both Henderson and Oswin models gave the most suitable models for describing the sorption data. The appropriate constants in the sorption equation were determined by regression analysis at temperature of 27°C. A comparison of the EMC curves showed that the toasted pupuru sample had lower equilibrium moisture contents than the smoked and oven dried samples at lower a_w but higher EMC at higher a_w.
Conclusion: It can also be concluded that the models are quite useful in assessing the storage stability of *pupuru* flour. The toasted *pupuru* flour has a higher sorption capacity and longer storage stability at higher a_w of the tropics than the other two samples at atmospheric temperature of 29°C.

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Keywords: Moisture; sorption; Pupuru; water activity; model; storage stability.

1. INTRODUCTION

The quality of most foods preserved by drying depends to a great extent upon their physical, chemical and microbiological stability. This stability is mainly a consequence of the relationship between the equilibrium moisture content (EMC) of the food material and its correspondence water activity (a_w), at a given temperature. These water sorption isotherms are unique for individual food materials and can be used directly to solve food processing design problems, predict energy requirement and to determine proper storage conditions (Fellow, 2003).

Water Sorption Isotherm equations can be used to predict water sorption properties of foods. There are many empirical and semi-empirical equations describing the sorption characteristics of foods. Sorption Isotherm precise shape is influenced by physical structure, chemical composition and extent of water binding within the food (Lomauro et al., 1985; Chen and Morey, 1989; Oyelade, 2008).

Pupuru is a traditional food in Nigeria widely consumed particularly among people from Western States. *Pupuru* is fermented traditionally by soaking cassava in water for about 3-5 days to become soft. After fermentation, the wet mash is packed into sack and dewatered in a mechanical press. The fibres are handpicked from the mash and are molded into ball or circular shape and placed over fire to smoke dry. The resulting products are spherical-like material with brown appealing appearance. The outer covering is then scraped off with knife and the inner white component is sieved into *Pupuru* flour.

The intent of this study therefore was to determine the sorption characteristics of *Pupuru* flour as to be able to predict its storage life at room temperature.

2. EXPERIMENTAL DETAILS

2.1 Preparation of *Pupuru*

Cassava tubers obtained from FUTA Research farm, were manually peeled, washed and steeped in water for four days until they were soft. At every 24 hours the water was decanted and replaced with fresh water in order to reduce the odour. After the fourth day the water was decanted, the soft wet mash was packed into Hessian sack and the water was allowed to drain off (Odetokun et al., 1998).

The fibres were manually removed and then divided into three portions. The first part was prepared into *pupuru* as it is done traditionally. It was moulded into small-sized balls or circular shape. The moulded balls were arranged on mat of palm fronds and was smoked using fire wood as heat source for 72 hours. The resulting products were spherical with brown appearance. The outer covering was scraped off with knife and the inner white component was pulverized and sieved into *pupuru* flour using Endicott laboratory Test Sieve with 60 mesh size.

The second portion of the dewatered meal was moulded into ball and dried in hot air oven (Gallenkhamp Model Oven- 160) at a set temperature of 60°C for 14hours (Osundahunsi, 2005). The product was pulverized and sieved with 60 mesh size to have oven dried *pupuru* flour.

The third portion of the wet cassava meal was sifted with a mesh 25mm pore size to remove shaft and fibre. The meal was toasted in wide aluminium pot with constant stirring for twenty minutes to prevent burning and formation of lumps. It was then milled into fine *pupuru* flour.

2.2 Determination of Equilibrium Moisture Content

The equilibrium moisture content of *pupuru* flours were determined by static gravimetric method as applied according to (Speiss and Wolf, 1985; Oyelade et al., 2001; Oyelade, 2008). For the adsorption process, the *pupuru* flours were dehydrated in a hot air oven to bone dry. Duplicate samples, 1.0±.001g each of smoked dried, ovens dried and toasted *pupuru* flour were weighed into moisture pans in the desiccators. The concentrated sulphuric acid quantities used to make up a 250ml of desiccant with deionised water was prepared at room temperature of 27°C, corresponding water activity (a_w) was dispensed into the desiccators. The desiccators were maintained at a_w values of 0.1, 0.2, 0.3, 0.4 and 0.60 respectively. The desiccators were kept at room temperature (27±2°C). Each of the samples was being weighed at two days intervals using a digital balance until constant weight was obtained in three consecutive recordings, then the sample was assumed to be at equilibrium (±0.001g).The bone dry mass was determined by the oven-drying method for 8hrs at 105±5°C (AOAC, 1990). The time to reach equilibrium ranged between 10 to 21 days depending on the water activity in each of the desiccators; those at higher water activities reaching equilibrium faster than those at lower water activities

2.3 Determination of Sorption Isotherm

The equilibrium moisture contents were calculated from which the moisture sorption Isotherms were plotted for the dried *pupuru* samples.

2.4 Sorption Equation

The experimental data were fitted to four commonly used models using linear regression analytical procedure. The models were the two parameter equations such as Henderson (Henderson, 1952); Chung Pfost (Chung and Pfost, 1967), Oswin (Oswin, 1946), and Caurie (Caurie, 1970). These models were chosen because of their suitability for high carbohydrate foods, simplicity and ease of evaluation (Ajisegiri et al., 2007). The quality of fitness of the models was evaluated by calculating coefficient of determination (r^2).

3. RESULTS AND DISCUSSION

The equilibrium moisture content at each a_w was used in plotting the adsorption isotherm of the varieties of *pupuru* flours at room temperature as shown in Figure 1. The equilibrium moisture content at each water activity (a_w) represents the mean of two determinations. The sorption isotherms have a sigmoid shape. This follows the classification of Brunauer et al. (1938), reported by Oyelade (1997) type II sorption isotherm curve indicating the efficacy of Raoult's law, capillary effects and surface water interaction.

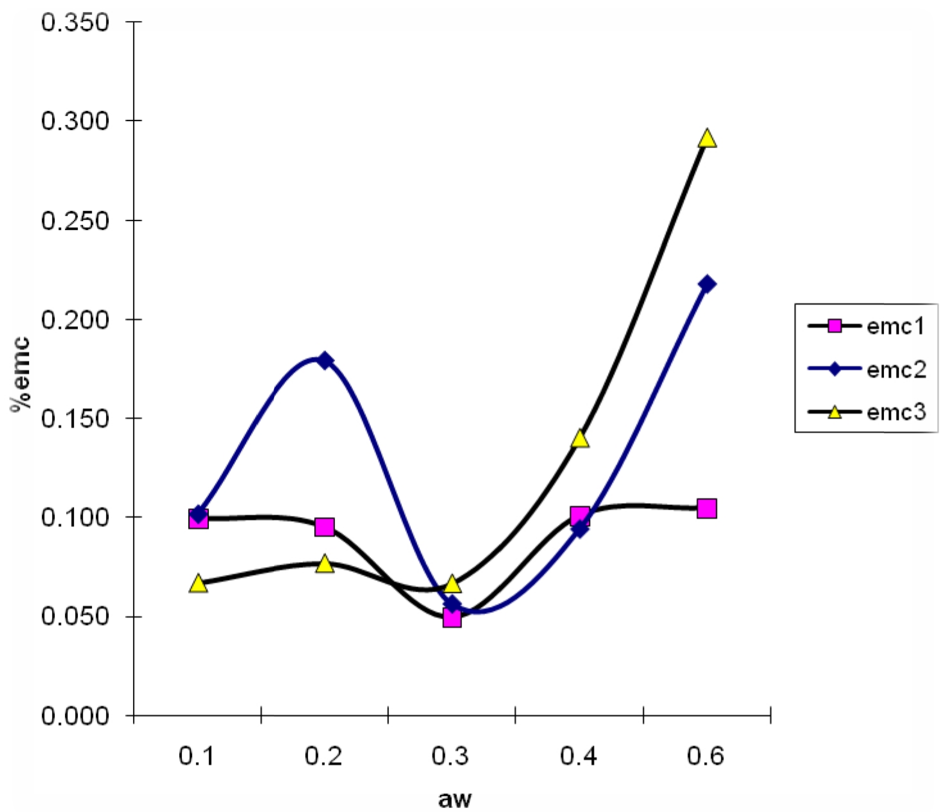

Fig. 1. Sorption isotherm curve for *pupuru* flour at 27°C
EMC 1 – Smoked dried Pupuru; EMC 2 – Oven dried Pupuru; EMC 3 – Toasted Pupuru

3.1 Effect of Water Activity on the Sorption Capacity of Pupuru Flour

The effect of water activity on the sorption capacity of the samples is shown in Figure 1. The equilibrium moisture content increased up to the water activity of 0.25, it reduces slightly until water activity of 0.35, and then it rose up again. At lower levels of water activity with small increase in a_w, there is slight increase in moisture content of the *pupuru* samples at ambient temperature. As water activity increases, the equilibrium moisture content increases sharply due capillarity. However, at higher water activity, greater than 0.35, slopes of the isotherms are much steeper producing large increases in equilibrium moisture content per unit water activity. This suggests that fluctuations in temperature and relative humidity will greatly have significant effect on storage stability of varieties of *pupuru* samples. Studying the curve it shows that increasing the relative humidity tends to increase the Equilibrium moisture content (EMC) at constant temperature. This is typical of isotherms of products high in starch content as observed by Onayemi and Oluwamukomi (1987) and Kumar (2000). The more the quantity of adsorbed moisture the higher the value of a_w which agrees with trend of increase in the equilibrium moisture content observed.

3.2 Effect of Drying Methods on the Sorption Characteristics of Pupuru Flour

The effect of drying methods on the sorption characteristics of pupuru can be appreciated by comparing the three curves in Figure 1. Increasing the relative humidity tends to increase the Equilibrium moisture content (EMC) at constant temperature. This is typical of isotherms of products high in starch content as observed by Onayemi and Oluwamukomi (1987) and Kumar (2000). A comparison of the EMC curves showed that the toasted pupuru sample had lower equilibrium moisture contents than the smoked and oven dried samples at lower a_w but higher EMC at higher a_w. This shows that toasted sample has higher sorption capacity and store longer at higher a_w than the other two samples. This must have been due to the effects of drying by toasting on fire and particle sizes as a result of differences in the processing and drying methods.

3.3 Fitting the Isotherm Models

The models fitted for *pupuru* flour using different drying methods are given Table 1. In fitting the curves, four models were implemented all of which were two variable models. The R^2 (coefficient of determination) value was employed in checking the goodness of each fit in each sample. It was observed that Oswin and Henderson equations had the highest value for R^2 which are 0.990 and 0.993 for smoked dried and toasted *pupuru* respectively. Chung and Pfost equation had the lowest value of R^2 which was 0.934. This result was similar to potato slice reported by Chen and Morey (1989).

Table 1. Parameter values for all model in adsorption

Model	Smoked Dried	Oven Dried	Toasted
Oswin			
A	0.566	0.525	0.450
B	1.557	1.415	1.436
R^2	0.990	0.881	0.993
Chung and Pfost			
A	-0.320	-0.589	-0.589
B	-0.024	-0.021	-0.021
R^2	0.934	0.972	0.972
Caurie			
A	0.373	0.481	0.428
B	-1.35	-1.507	1.422
R^2	0.986	0.945	0.985
Henderson			
A	0.506	0.583	0.515
B	1.642	1.814	1.692
R^2	0.981	0.945	0.991

A, B-- constants; R^2 -- coefficient of determination

In oven dried *pupuru*, Chung Pfost equation had the highest value for R^2 which was 0.972 and Oswin equation had the lowest value of R^2 of 0.945. Sanni et al., 1997 has reported similar result on tapioca grits.

Since these models were chosen because of their suitability for high carbohydrate foods, the closest the value of R^2 to 1 the better the model equation. It can therefore be said that

Oswin (1946) and Henderson (1952) equations are the best for smoked dried and toasted *pupuru*, while Chung and Pfost (1967) equation is the best for oven dried *pupuru*.

The parameters A and B were determined by regression analysis. It was observed (Table 1) that constant A gives the lowest value of moisture content at which the produce can be stored.

4. CONCLUSION

It can be concluded that toasted *pupuru* flour has a higher sorption capacity and longer storage stability at higher a_w of the tropics than the the smoked and oven dried samples at atmospheric temperature of 29°C. This study has been able to establish a better method for longer storage of *pupuru* flour.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Fig. 2. Oven dried *pupuru*

Fig. 3. Smoked-dried *pupuru* after 3 days
