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Research Article

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Developing Technology to Improve the Shelf Life of Sweet Potato Tubers

Dukuh, Isaac Gibberson*[1], Okyere, Justice[2] and Braimah, Maurice M[3]
[1]Department of Agricultural Engineering, Bolgatanga Polytechnic, Bolgatanga. Ghana
[2]Department of Agricultural Engineering, Wa Polytechnic. Ghana
[3]Department of Agricultural Engineering, Bolgatanga Polytechnic, Bolgatanga. Ghana
*Corresponding Author E-mail: isaacgdukuh@yahoo.co.uk

ABSTRACT

The study looked at measures for improving the storage life of sweet potato in the Coastal savanna zone of Ghana. Three varieties of sweet potato, TIS 86-3017, TIS 8266 and local variety, Local Cape Coast, were stored in a designed evaporative barn and storability of tubers was studied. Psychrometric studies of the barn showed that the evaporator reduced temperature and relative humidity variations inside the barn as compared to ambient conditions. Maximum daily temperature was reduced by an average of 3.2 ^{o}C. Minimum daily relative humilities were increased by an average of 7.3% in the evaporative barn and these could account for prevention of drastic reduction in weight and shrinkage. Storage of tubers in the barn reduced weight loss, weevil infestation and shrinkage of tubers as compared to room storage over a period of thirteen weeks. Varietal effect on weight loss, weevil infestation and fungal decay in storage was significant. The evaporative barn stored sweet potato tubers for between 5-10 weeks.

Key words: *Evaporative barn, Psychrometric studies, Shelf life, Sweet potato.*

INTRODUCTION

Sweet potato (*Ipomoea batatas* Lam.) is a dicotyledonous plant belonging to the family of *Convolvulaceae*. The contribution of sweet potato to the world's food production cannot be underestimated and according to Scott *et al.*[11] sweet potato is likely to increase its importance over the next 20 years. In Ghana sweet potato is grown mainly by peasant and small-holder farmers in Upper East and Central Regions where about 93,603 metric tonnes of sweet potato are cultivated. There exist a large number of cultivars which differ from one another in the root skin colour (white, creams, yellow, brown, orange or purple), flesh colour (white, creams, yellow orange or purplish red), the sizes and shape of roots and leaves, the depth of rooting, the time to maturity, the resistance to disease and in the texture of cooked roots [9,14]. The rapid population growth and pressure on land use in developing countries, is resulting in a massive rural-urban migration and a shortfall in food production. These are creating food shortage and malnutrition. However the expansion and intensification of agricultural production to meet food demand may severely affect the environment adversely. Lieberman[7] postulated that an alternative solution to the problem of meeting increasing food demand, is to reduce post harvest losses by improving storage and conservation or processing. Curing of sweet potato roots before storage as a standard procedure have been documented[5,6,12] since wounds created during handling become healed and coated with suberin which protects the root against pathogenic invasion[13].

Sweet potato has a few advantages, which can gives it an important role in meeting food shortages and malnutrition in tropical developing countries such as Ghana. The crop even strives well on marginal lands. It is also a famine-reserved crop and draught-tolerant crop. Sweet potato is ranked highest in nutritional value amongst other root crops. It is fat-free and contains beta carotenes, vitamins (A, C and E), magnesium, potassium and antioxidants.

In spite of the desirable traits listed above that sweet potato possesses, its utilization in many countries has declined. According to Woolfe[14], this can partly be due to pre- and post-harvest losses resulting in excessive waste which has increased prices thereby making it unattractive to those searching for a low cost nutrition substitute for more expensive and prestigious foods. In most tropical developing countries including Ghana, sweet potato roots have short shelf-life of only 1-2 weeks[10] and this presents the most serious constraint to the production and storage of sweet potato. Birago[1] has revealed that sweet potato farmers in the Cape Coast Metropolis, Ghana, do not store their harvested sweet potato at all because of high deterioration in storage due to inappropriate storage technology. Fungal diseases, insect pests, mites, nematodes and rodents combine in different ways under varying environmental conditions to cause high deterioration of the roots after harvest. Mariga[8] recorded post harvest losses due to pest and diseases as much as 60 % of the crop for a growing season.

Storage structure plays a major role in the storage system of the sweet potato. In Ghana sweet potato is stored by leaving it in the mounds even when matured, which ties the soils down to the crop and lead to fibrous roots and high weevil infestation. A few farmers stored in lined pits and on floors of dark airy rooms but losses are heavy.

Research efforts to determine and recommend cultivars which can withstand rough handling and store better under tropical condition can be of great benefit to sweet potato farmers and lead to increased utilization of sweet potato. The research looked at developing improved storage method which will promote whole crop harvesting and discourage mound storage which ties the soils down to the crop. Improved storage method will increase the availability of sweet potato tubers throughout the year at current production levels. Improved storage will also add value to the crop which will consequently increase returns to the farmers and can lead to improving their standard of living. The research is also important because it aims at determining varieties which have greater storability. This is in response to the need for improved methods of reducing pre- and post-harvest losses and discourages mound storage, which ties the soils down to the crop.

The main objective of this project is to improve storage of sweet potato in the coastal savannah zone of Ghana.

The specific objectives are:

- To investigate the extent to which ventilated barns and evaporative cooling can improve the storage of sweet potato tubers.
- To identify varieties which have greater storability.

MATERIALS AND METHODS

Two improved varieties; TLS 86-3017 and TIS 8266 and a local Cape Coast Variety were bulked, cured and stored in evaporative barn and in a room. The experimental design was a Randomized Complete Block with two factors. The treatments were factorial combination of 3 varieties and 2 storage structures.

Barn Construction and Storage of Tubers

A barn was designed and three replicates of it were constructed at the Technology Village of the School of Agriculture, University of Cape Coast. Cured tubers from the three varieties were bulked and stored in the barns and in a room. For each treatment fifty kilograms of tubers were used. The barn construction involved initial selection of site and type of building, material selection, calculation of load in structure, beam and column design. Psychrometric characteristics of storage barn and room were recorded.

Data Collection and Analysis

The following data were collected: weight loss in storage, degree of shrinkage, tuber decay, weevil infestation and Psychrometric characteristics of storage barn.

Analyses of variance for the tests were performed using the MSTAT-C statistical package. Mean separation was done using Duncan´s Multiple Range Test.

RESULTS AND DISCUSSIONS

Barn Storage Versus Room Storage

Table 1shows that at 5 weeks weight losses of tubers in the barns were not significantly different (p = 0.05) from weight loss of tubers in the room. Mean weight loss of tubers in the barn and room were 11.3% and 9.3% respectively. However, tuber weight loss in the room was significantly higher than weight loss in the barn (p = 0.01) at 13 weeks. Mean weight loss recorded for tubers stored in the room and in the barn were 62.0% and 31.9% respectively. The reduced weight loss of tubers in the barn could have been achieved by the generally higher relative humidity and lower temperature within the barn. There was also less weevil infestation of tubers in the barn, which could have contributed to lower weight loss of tubers in the barn.

The effect of storage structure on tuber shrinkage was highly significant at 5 weeks as shown in Table 1. Shrinkage of tubers was higher in room storage than in barn storage, which were 3.2% and 2.2% respectively. This difference could be attributed to the higher relative humidity maintained in the barn provided by the evaporators which reduced moisture loss and shrinkage of tubers. This finding is supported by similar findings by Ezel *et al*.,[4] who stated that the moisture content of stored tubers and their fresh weight loss were directly associated with the relative humidity of the storage condition. The differences in the extent of shrinkage of tubers in the barn and tubers in the room were highly significant in TIS 8266 and Local Cape Coast variety.

Table 1: Effect of Storage Structure on Cumulative Weight Loss at 13 Weeks and Tuber Shrinkage at 5 Weeks

Storage Structure	Cumulative Weight Loss (%) 13 weeks	Cumulative Tuber shrinkage (%) 5 Weeks
Room	62.0 a	3.2
Barn	31.9 b	2.2
	P = 0.01	P = 0.01

Table 2: Effect of Storage Structure on Mean Number of Weevils Among Tubers and Tuber Decay at 13 Weeks

Storage Structure	Mean Number of Weevils among Tubers	Cumulative Tuber Decay (%) 13 Weeks	Cumulative Tuber Decay (%) 13 Weeks
Room	36 a	12.5	97.5
Barn	9 b	13	41.5
	P = 0.01		P = 0.01

P values indicate level of significance differences between means.

Table 2 shows the mean number of weevils found among tubers in storage. Mean number of weevils found among tubers was 36 for room storage and 9 for barn storage. There was significantly higher number of weevils in tubers stored in room than in tubers stored in the barn (P = 0.01). The storage structure or evaporative barn was thus effective in controlling number of weevils found on tubers. The slatted floors with ventilation from underneath did not provide hiding places for the weevils and this could have resulted in low number of weevils found on tubers in the barn.

Table 2 also shows the rate of tubers decay in storage. After 13 weeks of storage percentage fungal decay was 41.5% and 97.5% for barn and room storage respectively. For longer periods of storage barn storage was far better than room storage. No significant difference in percentage fungal decay in tubers was observed between room storage and barn after 5 weeks of storage at 5% level. However fungal decay was slightly higher in the barn than in the room. Percentage decay in tubers in the barn and tubers in the room were 13% and 12.5% respectively. This could be attributed to the moisture content of tubers and the rate of water loss in tubers rather than conditions in storage. Diamante and Data[3] reported that the effectiveness of storage method depended to some extent on the varietals susceptibility to diseases. However, they observed slightly higher percentage fungal decay of tubers in the barn than tubers in the room at 5 weeks could have resulted from higher relative humidity in the barn, which favoured fungal growth in tubers.

VARIETAL EFFECT ON STORABILITY OF TUBERS

Tables 3 shows there were significant differences among the three varieties in their performance with respect to weight loss in the barn and in the room. TIS 8266 (V3) in room storage recorded the highest weight loss of 70.2%, while TIS 86 3017 (V2) in barn recorded the lowest weight loss of 29.0%.Varietal differences in percentage decay of tubers were highly significant (P = 0.01) as shown in Table 4. Variety and storage structure (storage method) interactions were significant in affecting decay in storage. TIS 8266 was more resistant to decay than TIS 86 3017 and Local Cape Coast varieties both in room storage and in the barn storage suggesting that, TIS 8266 have thicker skin which them resistant to decay in storage. The Local Cape Coast variety was less resistant to fungal decay than TIS 86 3017 and TIS 8266 both in room and in the barn storage. Thus varietals traits determine to some extent the effectiveness of a storage method, which agrees with observation made by Diamante and Data[3]. The heavy weevil infestation of tubers in the room after 13 weeks of storage could also account for the higher fungal decay of tubers in the room than tubers in the barn. Weevil infestation rendered tubers in the room unacceptable as compared to tubers in the barn after 13 weeks of storage.

Table 3: Effects of Variety and Storage Method Interaction on Cumulative Weight Loss and Shrinkage of Tubers

Storage Structure	Varieties	Cumulative Wt. loss (%) 13Wks.	Shrinkage (%) at 5 Wks.
Room	V3	70.2 a	6.0 a
	V1	64.9 a	2.6 c
	V2	50.9 a	0.8 e
Barn	V1	33.3 d	1.9 d
	V3	32.3 c	3.6 b
	V2	29.0 e	1.0 e
		P = 0.01	P = 0.01

C. V. 12.19% C. V. 17.69%

Table 4: Effects of Variety and Storage Method Interaction on Fungal Decay of Tubers

Storage Structure	Varieties	Tuber Decay (%) at 5 Weeks.	Cumulative Tuber Decay (%) 13 Weeks
Room	V1	20.1 a	97.5 a
	V2	13.5 d	
	V3	5.4 e	
Barn	V2	18.0 b	41.5 b
	V1	16.1 c	
	V3	3.4 f	
		P = 0.01	P = 0.01

C. V. 12.19%

PSYCHROMETRIC CHARACTERISTICS OF EVAPORATIVE COOLING BARN.

Temperature, relative humidity, moisture content of air, enthalpy and specific volume of air inside the barn and ambient conditions were determined.

Fig. 1: Comparative Study of Temperature Behaviour of Evaporative Barn, Ambient

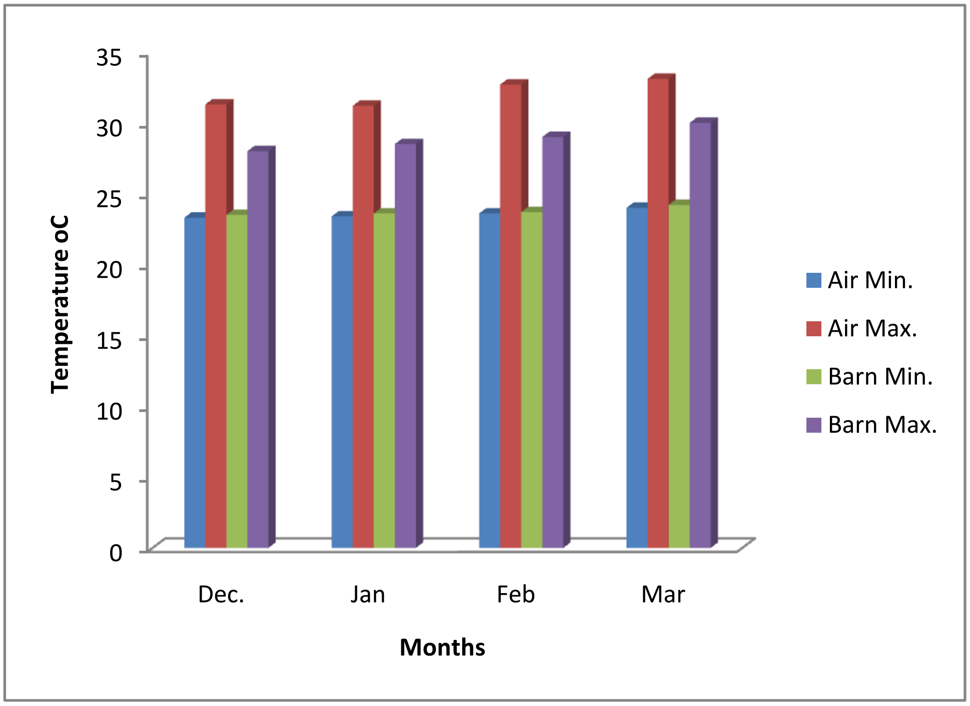
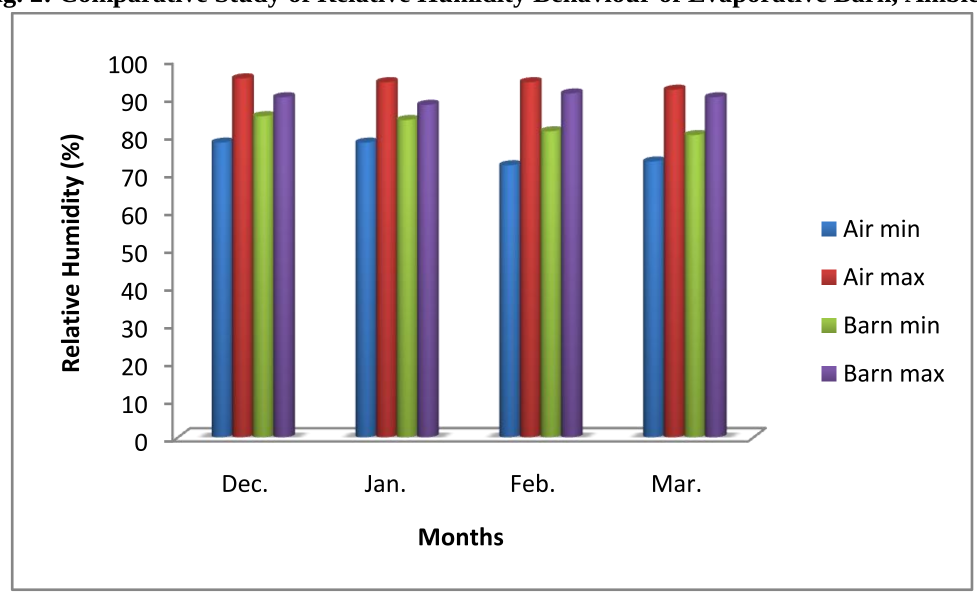


Fig. 2: Comparative Study of Relative Humidity Behaviour of Evaporative Barn, Ambient



TEMPERATURE AND RELATIVE HUMIDITY OF AMBIENT AND INSIDE THE BARN

Figure 1 shows mean monthly maximum and minimum temperature of ambient and inside barn. The result shows that maximum air temperature increased from 31.3^{0} C in December to 33.1^{0} C in March, the following year. Figure 1 also shows that the variation between maximum and minimum temperature was lower inside the barn than ambient because of the effect of the evaporator. Inside the barn maximum temperature ranged from 28^0 C to 30^o C during the study period. The variation between the minimum and maximum temperature was lower inside the barn than that of the surrounding air because the evaporator tended to prevent high temperature build up (afternoon temperature) inside the barn. It was also observed that night minimum temperatures inside the barn were higher than that of the ambient and this could be the result of respiratory heat produced by tubers and the cladding of the slated walls with jute sacks which maintained comparatively stable air conditions inside the barn.

RELATIVE HUMIDITY OF AMBIENT AIR AND INSIDE THE BARN

Figure 2 shows mean monthly maximum and minimum relative humidity of ambient and inside the barn. The minimum relative humidity of ambient decreased from 78% in December to 72% in February, the following year. Inside the barn minimum relative humidity decreased from 85% in December, to 80% in March, the following year.

MEAN MONTHLY ENTHALPY, MOISTURE CONTENT AND SPECIFIC VOLUME OF AIR INSIDE THE BARN

Table 5 shows mean monthly moisture content of air ranged from 0.023kg/kg to 0.0236kg/kg in March when mean monthly ambient temperature was highest. Moisture content of air inside the barn ranged from 0.0238kg/kg in December to 0.0246kg/kg in March, the following year. Table 5 shows that air enthalpy ranged from 91kJ/kg to 94.5kJ/kg.

Table 5: Mean Monthly Enthalpy, Moisture Content and Specific Volume of Air Inside the Barn

Months	Enthalpy, kJ/kg		Specific Volume, m^3/kg		Moisture content	
	Air	Barn	Air	Barn	Air	Barn
Dec.	91	90	0.887	0.885	0.0230	0.0238
Jan.	91	90	0.887	0.885	0.0230	0.0238
Feb.	93	90	0.888	0.885	0.0230	0.0236
Mar.	94.5	93.5	0.891	0.889	0.0236	0.0246

CONCLUSSION

The improved varieties of potato were more resistant to weevil infestation and to decay than the local variety during storage. Barn storage improved sweet potato storage by reducing weight loss, shrinkage, fungal decay and level of weevil infestation of tubers in storage as compared to the traditional room storage. The evaporator reduced variation in temperature and relative humidity in the evaporative barn. Specific enthalpy changes between surrounding air and air inside the evaporative barn were very negligible because the process of cooling the barn was evaporative cooling, which was an adiabatic process. Wet-bulb depression was small and therefore increases in relative humidity and temperature drop in the barn were not large.

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