Original Research Article

EFFECT OF SOME STORAGE METHODS ON THE QUALITY OF MAIZE GROWN IN THE ASHANTI MAMPONG MUNICIPALITY OF GHANA

ABSTRACT

This study aims at finding an acceptable storage method for three varieties of Maize grown in the Ashanti Mampong Municipality of Ghana. Survey and standard laboratory protocols were carried out to gather the necessary data for the study. The background study revealed that 18%, 13%, 24%, 15%, 12%, 8% and 10% of farmers store their maize by heaping on the floor, storing in cribs, conventional jute sack, plastic drum, clay pot, triple-layer hermetic bag and polypropylene respectively. The findings also indicated that moisture loss was reduced in the plastic drum and triple-layer hermetic bag after the four months of storage. The proximate composition of the stored produce showed that maize preserved better in the triple layer hermetic bag. It is recommended that the triple-layer hermetic bag should be extensively used in storing maize as it has the ability to reduce moisture loss, and also preserving the nutritional and market value of the produce stored in it.

INTRODUCTION

Maize is the most widely produced and consumed cereal crop in Ghana [7]. Most of the farmers aim at increasing the quantity of their maize, but do not obtain the expected income of their efforts because a chunk of the produce which are not sold within a stipulated time, spoil or are sold at a cheaper price, owing to the fact that there is lack of proper storage facilities [4]. Maize grains storage is very important component in the economics of developing and developed countries alike, but developing countries suffer severe qualitative and quantitative postharvest losses due to the choice and use of storage methods [9].

The availability and safety of maize is threatened by insect pests, rodents and fungal attack due to inappropriate storages methods. Infestation by insect-pest accounts for between 29 to 50% of postharvest losses in maize []. Apart from the actual nutrient losses, kernels damaged by insects may be contaminated with aflatoxins. Additionally, there is contamination by dead beetles, pupae, frass and larval cocoons, some of which contain substances such as ethyl, methyl and methoxy quinines which are heat resistant therefore cannot be destroyed by boiling or baking. The widespread use of synthetic chemicals results in the development of resistant insect strains.

The use of hermetic storage is now becoming widespread, using modern low permeability plastic materials which are light in weight and can be used indoors or outdoors.

Triple-layer hermetic bags have been used to control cowpea bruchids, (*Callosobruchus muculatus*), *Dinoderu spp* and *P. truncates* on cassava chips with very promising results [6]. However, little is known about the effect of the triple layer bags on the proximate composition of stored maize. Therefore, this study aimed at finding the best storage alternative for harvested maize by comparing the effect of three storage methods on the quality of the three varieties of maize produced in the Mampong Municipal Area of Ashanti Region of Ghana.

MATERIALS AND METHODS

Study Area and Scope of the Study

This study was conducted in four (4) communities namely, Kyeremfaso, Asaam, Kofiase and Pintin, all within the Mampong municipal area of Ashanti Region of Ghana. Structured questionnaires were designed for data collection. A total of one hundred and sixty maize farmers in the municipality were sampled for the research, forty from each of the four communities.

Source of Maize for Laboratory Work

Three bags each of three different varieties of maize namely 'Mamaba', 'Dobidi' and 'Dadaba' were purchased from the Municipal Office of Ministry of Food and Agriculture (MOFA) Mampong-Ashanti branch.

Source of Storage Materials

The triple layer hermetic bags were supplied by Bio plastics (a local manufacturer of the hermetic bag). The Jute sacks and plastic containers were also purchased from Kyeiwaa Enterprise, a certified agro-chemical and equipment shop at Ashanti Mampong.

Experimental Design

The experimental design was 3 x 3 factorial laid in a Complete Randomized Design (CRD) with four replications. The experimental factors were;

Factor A; storage methods at three (3) levels, namely; Jute sack, Triple-layer hermetic bag and Empty plastic drum (treated with actellic super chemical)

Factor B; Three maize varieties grouped into A, B and C, with 'A' representing Dobidi, 'B' representing Mamaba and 'C' representing Dadaba. The treatments were replicated four (4) times on each of the maize varieties as follows A1, A2, A3, A4, , B1, B2, B3, B4, and C1, C2, C3, C4, .Cardboards were used as tags, to identify the treatments and the replicates.

Application of Actellic Super

Twenty Millilitres of Actellic super was dissolved in 100 ml of water and applied to 50kg each of the varieties of maize used for the experiment. The maize was then dried on a concrete floor for three days before being packed into the plastic drum.

Parameters studied and Data Collection

Data was collected between the periods, November 2013 to February, 2014 on the following parameters; moisture content, proximate composition analysis and germination potential.

Determination of Moisture Content

Moisture content was measured at the end of every month using the dry method (Indirect Distillation Method). In this method, the moisture can or crucibles were initially weighed, followed by weighing 1 kg of each variety of maize. The samples were then allowed to dry overnight in an air oven at 65°C for 24 hours and then cooled in a desiccator together with the crucibles, after which the new weight was taken. The results were recorded in triplicate.

The following calculations were employed to arrive at the final percentage moisture of the two different samples;

(A+B) – A = B

(A+B) – (A+C) = B – C = D

% Moisture = D/B x 100

Where A= crucible weight, B = sample weight, C = dry weight, D = moisture weight.

Determination of Viability/Germination Potential

The seed viability test was conducted before and after the four months of storage. The results of these two were compared to see if storage has any effect on seed viability. Seeds was randomly taken from the various bags and cultured in Petri dishes containing filter paper and water. These were covered and cultured for seven days and observed for emergence. It was replicated five times with controls from the original seeds before storage. On the seventh day, the germinated seeds from each Petri dish were counted.

The viability or germination potential was calculated using the formula:

Germination potential, $Gp = \frac{Ng}{Nt} \times 100\%$

Where Ng = number of germinated seeds

Nt = total number of seeds in the sample or initial number of seeds in sample

Proximate Analysis of Maize Grain

Laboratory analyses were performed on samples of the three (3) varieties of maize before storage and after storage by following the protocol below.

Ash Determination

The dry method of ashing in accordance with [1], using Gallenkamp Muffle Furnace, England was followed to determine the percentage of ash.

Ash crucible was removed from the oven, placed in a desiccator to cool and weighed.

2.0g of the samples were placed in a porcelain crucible in triplicate. The samples were then put into the furnace for 4 hours at 550°C. The furnace was allowed to cool below 200°C for 20 minutes, and finally the crucible was placed in a desiccator with stopper top to cool and then weighed.

The following calculations were employed to arrive at the final percentage ash of the samples and results recorded in triplicate.

$(A + B) – A = B$

$(A + C) – A = C$

$\% \text{ Ash} = C/B \times 100$ Where A = crucible weight, B = sample weight, C = ash weight.

Ether Extract (Fat) Determination

The percentage fat in the three (3) varieties of maize was determined using the following;

Whatman No. 2 filter paper, Absorbent cotton wool and Soxhlet apparatus.

Procedure:

A piece of paper was folded in such a way to contain the samples, after which a piece of cotton wool was placed at the top to evenly distribute the solvent as it drops on the sample during extraction. The sample packet was placed in the butt tubes of the Soxhlet extraction apparatus. Petroleum ether was used to do the extraction with gentle heating for 2 hours without interruption.

The extract was allowed to cool to a temperature of 5°C whilst the extraction flask was dismantled. The ether was allowed to evaporate on a steam or water bath at a temperature of 90°C until no odour of ether remained. Dirts or moisture that accumulated outside the flask were carefully removed or wiped and the flask was weighed.

Calculations:

(A + B) – A = B

% ether extract = B/C x 100

Where A = flask weight, B = ether extract weight, C = sample weight.

Crude Protein determination

The Macro Kjeldahl procedure which is based on the [1] method 984.13 was used. The resultant protein content of the samples was determined in triplicate by analysing the total nitrogen present and converting it to protein with the aid of the conversion factor 6.25. The end result was recorded in percentage (%).

The nitrogen content of the samples was calculated using the following formula.

$$N\ (gkg^{-1}) = \frac{(ml\ HCl - ml\ blank) \times Normality \times 14.01)}{Weight\ of\ sample\ (g) \times 1}$$

Determintion of Crude Fibre

The dietary fibre content was determined using the Van Soest detergent method [10]..

Determination of Total Carbohydrate

The differential method was used to determine the total Carbohydrate in the maize grain. This was done by subtracting the total protein, lipid, moisture and ash content from 100. Therefore, Total Carbohydrate = 100 – (% moisture + % ash + % fat + % protein + % fibre).

Experimental Design and Statistical Analysis

Data from the survey were analyzed for frequencies, percentages and Pearson's Chi-square test of association using SPSS 16. The mean values obtained from the proximate, vitamins and mineral analysis of the three varieties of maize before and after storage were also separated and compared using the t-test of the student edition of statistix 9.0.

RESULTS AND DISCUSSION

Table 1: Proximate composition of the Three Varieties of Maize Before (BS) and After Storage (AS)

Variety	Protein Content (%)		Moisture Content (%)		Ash Content (%)		Crude Fibre (%)		Fat Content (%)		Carbohydrate Content (%)	
	BS	AS	BS	AS	BS	AS	BS	AS	BS	AS	BS	AS
Mamaba	11.71a	11.37a	12.70a	11.51a	1.34b	1.71b	2.29a	2.26a	3.98b	3.13b	76.94b	74.85b
Dadaba	10.60b	9.55b	12.28b	11.60a	1.49a	1.89a	1.81b	1.57b	3.96b	3.03b	78.55a	76.83a
Dobibi	9.97c	8.57c	11.82c	11.38a	0.84c	1.04c	2.00b	1.65a	5.93a	4.77a	76.62b	74.58b

Table 1 shows the proximate composition of the three varieties of maize. The results indicate that there was no significant difference in protein, ash, fat and carbohydrate content before and after storage among the three varieties. Moisture content for Mamaba before storage and after storage also recorded no significant difference. However, there was a significant difference in moisture content, before and after storage between Dadaba and Dobidi varieties. Significant difference in crude fibre content was observed in the varieties studied before and after storage. The implication is that when the three varieties of maize are stored for a period of four months, its proximate composition in terms of protein, ash, fat and carbohydrate content remained significantly unchanged but its moisture and fibre content changed significantly.

The differences recorded in proximate composition among the three varieties could be attributed to the genetic differences that exist between the varieties.

Table 2: Germination Potential of Mamaba, Dadaba and Dobidi Varieties of Maize before and after Storage.

Varieties	Germination Test (%)	
	Before Storage	**After Storage**
Mamaba	98.00a	91.00a
Dadaba	95.00b	88.88b
Dobidi	94.66b	86.77b

Significance difference in the germination potential of the varieties studied was observed before and after storage. Mamaba had a greater germination percentage than Dadaba and Dobidi varieties both before and after storage. However, there was no significant difference in the germination potential of Dadaba and Dobidi varieties of maize before and after the four months of storage.

Table 3: Effect of Packaging Materials on ash Content

Varieties	Hermetic bag	Jute sack	Plastic drum	Means
Mamaba	1.61ab	1.31bc	1.09cd	1.34a
Dadaba	1.76a	1.92a	0.84de	1.52a
Dobidi	0.98b	1.10cd	0.66e	0.96b
Means	1.46a	1.44a	0.86b	

CV=9.52

HSD (0.01): Varieties=0.18 Packaging materials=0.19, Varieties *Packaging materials=0.42

There were significant (p≤0.01) difference in varieties and packaging materials interaction for ash content. Highest ash content was recorded by Dadaba variety which was packaged in the jute sack and the least was Dodobi packaged in plastic drum. Across the varieties, Mamaba and Dadaba produced the highest ash content and the least was Dobodi variety. With respect to the packaging materials, highest ash content was recorded by Hermetic bag and Jute sack whiles plastic drum produced the least. The decrease in ash content might have been due to the feeding activities of insect pests in the storage materials [2].

Table 4: Effect of Packaging Materials on Carbohydrate Content

Varieties	**Hermetic bag**	**Jute sack**	**Plastic drum**	**Means**
Mamaba	76.11ab	74.88b	73.67b	74.89b
Dadaba	78.40a	76.20ab	75.88ab	76.83a
Dobidi	75.22b	74.56b	74.65b	74.81b
Means	76.58a	75.21b	74.73b	

CV=0.96

HSD (0.01): Varieties=0.12 Packaging materials=1.13, Varieties*Packaging materials=2.53

There was significant (p≤0.01) difference in varieties and packaging materials interaction for carbohydrate content. Highest carbohydrate content was recorded by

Dadaba variety which was packaged in the hermetic bag and the least was Dobidi packaged in jute sack. Across the varieties, Dadaba produced the highest carbohydrate content and the least was Dobidi and Mamaba varieties. The difference in carbohydrate content could be due to the genetic differences between the varieties. In addition, the highest carbohydrate content in the maize stored in the hermetic bag could be due to the fact that it prevented exchange of gases between the maize and the storage environment. The jute bag and plastic drum allowed exchange of gases which led to oxidation and hydrolysis of carbohydrates in the maize, hence the low carbohydrate content.

Table 5: Effect of Packaging Materials on Crude Fibre Content

Varieties	**Hermetic bag**	**Jute sack**	**Plastic drum**	**Means**
Mamaba	2.21b	2.41a	2.08c	2.23a
Dadaba	1.72e	1.93d	1.11f	1.59c
Dobidi	1.79e	2.13bc	1.17f	1.70b
Means	1.91b	2.16a	1.45c	

CV=1.53

HSD (0.01): Varieties=0.03 Packaging materials=0.04, Varieties*Packaging materials=0.10

There was significant (*p≤0.01*) difference in varieties and packaging materials interaction for crude fibre content. Highest crude fibre was recorded by Mamaba variety which was packaged in the jute sack and the least was Dobodi and Dadaba packaged in hermetic bag. Across the varieties, Mamaba produced the highest crude fibre and the least was Dadaba variety. With respect to the packaging materials, highest crude fibre was recorded by jute sack whiles plastic drum produced the least. Crude fibre also saw a decrease in the Triple-layer hermatic bag and the plastic drum, with an increase in the maize stored in the Jute sack in all the three (3) varieties of maize after four (4) months of storage as shown in tables 5. The increase might be due to the activities of insect pests in the grains, leaving only the brand which is mostly fibre [2]. According to [8], the decrease in value of crude fibre content might also be due to the emergence of holes created by weevils, since the husk of the maize grain is rich in crude fibre.

Table 6: Effect of Packaging Materials on fat

Varieties	Hermetic bag	Jute sack	Plastic drum	Means
Mamaba	3.17cd	3.22cd	3.12cd	3.17d
Dadaba	3.75bcd	3.12cd	2.34d	3.07b
Dobidi	5.00b	4.67bc	9.630a	6.43a
Means	3.97b	3.67b	5.030a	

CV=12.30

HSD (0.01): Varieties=0.81 Packaging materials=0.80, Varieties*Packaging Materials=1.83

There was significant (p≤0.01) difference in varieties and packaging materials interaction for fat content. Highest fat was recorded by Dobidi variety which was packaged in the plastic drum and the least was Dadaba packaged in plastic drum. This could be due to the fact that Dadaba variety genetically had lower fat content as compared to Dobidi. Across the varieties, Dobidi produced the highest fat and the least was Dadaba and Mamaba varieties. With respect to the packaging materials, highest fat was recorded by plastic drum while jute and hermetic produced the least. It is possible that the rate of oxidation in the plastic drum was faster than in the hemetic bag. Rate of gaseous exchange in the hemetic bag was lower than in the jute bag. Since maize is not consumed due to its fat content, the variety with a lower fat (Dadaba) should use.

Table 7: Effect of Packaging Materials on Protein Content

Varieties	Hermetic bag	Jute sack	Plastic drum	Means
Mamaba	11.68a	11.270a	11.31a	11.42a
Dadaba	10.34b	9.44c	9.18c	9.65b
Dobidi	9.34c	8.66d	8.31d	8.77c
Means	10.45a	9.79b	9.60b	

CV=2.24

HSD (0.01): Varieties=0.35 Packaging materials=0.34, Varieties*Packaging materials=0.79

There was significant (p≤0.01) difference in varieties and packaging materials interaction for protein content. Highest protein was recorded by Mamaba variety which was packaged in all three materials and the least was Dobidi packaged in plastic drum. Across the varieties, Mamaba produced the highest protein and the least was Dobidi variety. Mamaba variety was released with the view of solving the protein malnutritional needs. Its highest protein content could due to the differences in the genetic make-up of the three varieties used. With respect to the packaging materials, highest protein was recorded by hermetic while jute and plastic drum produced the least. Storage of Dobidi maize variety in the plastic drum reduced protein and this could be due to the quicker denaturation of proteins due to the heat build-up in the plastic drum.

CONCLUSION

The Triple-layer hermetic bag was more effective in storing maize. Although there was a general reduction in the proximate composition of the stored maize at the end of the storage period, the Triple-layer hermetic bag, being air-tight, was able to conserve protein, moisture, carbohydrate and also, reduced crude fibre and ash content in the maize stored in it. The jute sack also performed better than the plastic drum in all proximate analysis factors except the fat content.

In conclusion, the following findings were made from the study:

i. Highest carbohydrate and ash content were recorded by Dadaba variety which was packaged in the hermetic bag.
ii. Highest fat was recorded by Dobidi variety which was packaged in all the three materials.
iii. Highest protein was recorded by Mamaba variety which was packaged in all the three materials.
iv. Hermetic bag significantly maintained maize quality (fat, protein, carbohydrate, and ash) as compared to jute bag and the plastic drum.

RECOMMENDATIONS

Based on the results of the study, the following recommendations were made;

Triple-layer hermetic bag should be used extensively in storing maize, as it has the capacity to reduced moisture loss, and also, preserving the nutritional and market value of the produce.

Finally, further study should be conducted on the storage of the three varieties of maize using other methods and beyond four months of storage, to ascertain the keeping quality of the maize.

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