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## Original Research Article

### **EFFECT OF THREE STORAGE METHODS ON THE QUALITY OF THREE VARIETIES OF STORED MAIZE IN THE ASHANTI MAMPONG MUNICIPALITY OF GHANA**

#### **ABSTRACT**

This study was aimed at finding an acceptable storage method for three (3) 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 study revealed that 18%, 13%, 24%, 15%, 12% and 18% 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 (4) 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, insect pest infestation, respiratory activities of stored grains and also preserving the nutritional and market value of the produce stored in it.

Comment [A1]: Percentages provided were six but methods of storage stated were seven. That was incorrect

Comment [A2]: If insect pest infestation, respiratory activities were not assessed how can the researcher draw this conclusion

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UNDER PEER REVIEW

31 | **INTRODUCTION**

32 | Maize is the most widely produced and consumed cereal crop in Ghana [6]. Most of the  
33 | farmers aim at increasing the quantity of their maize, but do not obtain the expected  
34 | income of their efforts because a chunk of the produce which are ~~in excess or are not~~  
35 | sold within a stipulated time, spoil or are sold at a cheaper price, owing to the fact that  
36 | there is lack of proper storage facilities. Maize grains storage is very important  
37 | component in the economics of developing and developed countries alike, but  
38 | developing countries suffer severe qualitative and quantitative postharvest losses due to  
39 | the choice and use of storage methods [8].

40 | The availability and safety of maize is threatened by insect pests, rodents and fungal  
41 | attack due to inappropriate storages methods. Infestation by insect-pest accounts for  
42 | between 29 to 50% of postharvest losses in maize [4]. Apart from the actual nutrient  
43 | losses, kernels damaged by insects may be contaminated with ~~dangerous levels of~~  
44 | aflatoxins. Additionally, there is contamination by dead beetles, pupae, frass and larval  
45 | cocoons, some of which contain ~~highly dangerous~~ substances such as ethyl, methyl and  
46 | methoxy quinines which are heat resistant therefore cannot be destroyed by boiling or  
47 | baking. The widespread use of synthetic chemicals ~~has led to some serious problems,~~  
48 | ~~including results in the~~ development of resistant insect strains.

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

52 | Triple-layer hermetic bags have been used to control cowpea bruchids,  
53 | (*Callosobruchus* ~~*maeulates*~~ *muculatus*), *Dinoderu\_spp* and *P. truncates* on cassava

54 chips with very promising results [5]. However, little is known about the effect of the  
55 triple layer bags on the proximate composition of stored maize.

56 The study therefore aimed at finding the best storage alternative for ~~their~~ harvested  
57 maize by comparing the effect of three (3) storage methods on the quality of the three  
58 (3) varieties of maize produced in the Mampong Municipal Area of Ashanti Region of  
59 Ghana.

**Comment [A3]:** Your previous statement stated 7 methods not 3. Inconsistency revealed some weakness in conclusion drawn

## 61 MATERIALS AND METHODS

### 62 Study Area and Scope of the Study

63 The study was conducted in four (4) communities i.e. Kyeremfaso, Asaam, Kofiase and  
64 Pintin all within the Mampong municipal area of Ashanti Region of Ghana. Structured  
65 questionnaires were designed for data collection. A total of one hundred and sixty (160)  
66 maize farmers in the municipality were sampled for the research, forty (40) from each  
67 of the four (4) communities.

**Comment [A4]:** Which include

### 69 Source of Maize for Laboratory Work

70 Three bags each of three different varieties of maize namely 'Mamaba', 'Dobidi' and  
71 'Dadaba' were purchased from the Municipal Office of Ministry of Food and  
72 Agriculture (MoFA) of Ghana.  
73

**Comment [A5]:** From each municipality of the 4 communities or from one community?

### 74 Source of Storage Materials

75 The triple layer hermetic bags were supplied by Bio plastics (a local manufacturer of  
76 the hermetic bag). The Jute sacks and plastic containers were also purchased from a  
77 certified Agro-chemical and equipment shop at Ashanti Mampong.  
78

**Comment [A6]:** Mention the name of the dealer

79

## 80 **Experimental Design**

81 The experimental design was 3 x 3 x 4 factorial laid in a Complete Randomized Design  
82 (CRD) with four replications. The experimental factors were;

83 Factor A; storage methods at three (3) levels, namely;

84 i. Jute sack

85 ii. Triple-layer hermetic bag

86 iii. Empty plastic drum (treated with actellic super chemical)

87 Factor B; Three (3) maize varieties grouped in-to A, B and C, with 'A' representing  
88 Dobidi, 'B' representing Mamaba and 'C' representing Dadaba. The treatments were  
89 replicated four (4) times on each of the maize varieties as follows A1, A2, A3, A4, ,  
90 B1, B2, B3, B4, and C1, C2, C3, C4, .Cardboards were used as tags, to identify the  
91 treatments and the replicates.

92

## 93 **Application of Actellic Super**

94 Twenty Millilitres (20mls) of Actellic super was dissolved in 100mls of water and  
95 applied to each of the varieties of maize used for the experiment. The maize was then  
96 dried on a concrete floor for three (3) days before being packed into the plastic drum.

97

## 98 **Parameters studied and Data Collection**

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

102

103

**Comment [A7]:** This is wrong  
Your design is 3\*3

Treatments 3 \*3 = 9 because line 90-98  
stated only 2 factors(storage method and  
Variety)

Replications = 4

Total treatments units therefore = 9 \* 4 =  
36units

If you write 3\*3\*4 implies that you have 3  
factors 2 with 3 levels and one with 4 levels  
that's was shown from line90-98

**Comment [A8]:** What quantity of maize  
?

**Comment [A9]:** Line 18-24 did not  
capture anything on germination potential  
as part of conclusion drawn

104 **Determination of Moisture Content**

105 Moisture content was measured at the end of every month using the dry method  
106 (Indirect Distillation Method). In this method, the moisture can or crucibles were  
107 initially weighed, followed by weighing 1 Kg of each variety of maize. The samples  
108 were then allowed to dry overnight in an air oven at 105°C for 24 hours and then  
109 cooled in a desiccator together with the crucibles, after which the new weight was  
110 taken. The results were recorded in triplicate.

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

113  $(A+B) - A = B$

114  $(A+B) - (A+C) = B - C = D$

115 % Moisture =  $D/B \times 100$

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

117

118 **Determination of Viability/Germination Potential**

119 The seed viability test was conducted before and after the four (4) months of storage.

120 The results of these two were compared to see if storage has any effect on seed

121 viability. Seeds was randomly taken from the various bags and cultured in Petri dishes

122 containing filter paper and water. These ~~were was~~ covered and cultured for seven (7)

123 days and observed for emergence. It was replicated five (5) times with controls from

124 the original seeds before storage. On the seventh day, the germinated seeds from each

125 Petri dish were counted.

126 The viability or germination potential was calculated using the formula:

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

128 Where Ng = number of germinated seeds

**Comment [A10]:** 105C not is too high.  
At what percent of the moisture was it initially before storage?

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

130

### 131 **Proximate Analysis of Maize Grain**

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

134

### 135 **Ash Determination**

136 The dry method of ashing in accordance with AOAC (1990), using Gallenkamp Muffle  
137 Furnace, England was followed to determine the percentage of ash.

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

139 2.0g of the samples were placed in a porcelain crucible in triplicate. The samples were  
140 then put into the furnace for 4 hours at 550°C. The furnace was allowed to cool below  
141 200°C for 20 minutes, and finally the crucible was placed in a desiccator with stopper  
142 top to cool and then weighed.

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

$$145 (A + B) - A = B$$

$$146 (A + C) - A = C$$

147 % Ash =  $C/B \times 100$  Where A = crucible weight, B = sample weight, C = ash weight.

### 148 **Ether Extract (Fat) Determination**

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

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

152

### 153 **Procedure:**

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

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

164 Calculations:

$$165 (A + B) - A = B$$

$$166 \% \text{ ether extract} = B/C \times 100$$

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

168

#### 169 **Crude Protein determination**

170 The Macro Kjeldahl procedure which is based on the AOAC (1990) method 984.13  
171 was used. The resultant protein content of the samples was determined in triplicate by  
172 analysing the total nitrogen present and converting it to protein with the aid of the  
173 conversion factor 6.25. The end result was recorded in percentage (%).

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

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

175

176 **Determination of Total Carbohydrate**

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

**Comment [A11]:** Procedure for fibre not shown

181

182 **Experimental Design and Statistical Analysis**

183 Data from the survey were analyzed for frequencies, percentages and Pearson's Chi-  
184 square test of association using SPSS 16. The mean values obtained from the  
185 proximate, vitamins and mineral analysis of the three varieties of maize before and after  
186 storage were also separated and compared using the t-test of the student edition of  
187 statistix 9.0. Finally, data on insect holes in maize, life and dead insects and colour  
188 change of maize after storage were also analysed using the student edition of statistix  
189 9.0.

**Comment [A12]:** How were these parameters assessed

190

191

192

193 **RESULTS AND DISCUSSION**

194

195 **Table 1: Proximate composition of the Three Varieties of Maize Before (BS) and**  
 196 **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

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198 Table 1 shows the proximate composition of the three (3) varieties of maize. The  
 199 results indicate that there was no significant difference in protein, ash, crude fibre, fat  
 200 and carbohydrate content before and after storage among the three varieties. Moisture  
 201 content for Mamaba before storage and after storage also recorded no significant  
 202 difference. However, there was a significant difference in moisture content, before and  
 203 after storage between Dadaba and Dodobi varieties. The implication is that when the  
 204 three varieties of maize are stored for a period of four months, its proximate  
 205 composition in terms of protein, ash, crude fibre, fat and carbohydrate content and  
 206 remained significantly unchanged but its moisture content changed significantly.

**Comment [A13]:** Check values for crude fibre, there was a significant difference among the means after storage

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207 The differences recorded in proximate composition among the three (3) varieties could  
 208 be attributed to the genetic differences that exist between the varieties.

209

210

211 **Table 2: Germination Potential of Mamaba, Dadaba and Dobidi Varieties of**  
 212 **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

213

214 There was no significant difference in the germination potential of Mamaba, Dadaba  
 215 and Dobidi varieties of maize before and after the four (4) months of storage.

216

217 **Table 3: Effect of Packaging Materials on ash Content**

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

218 **CV=9.52**

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

221 There were significant ( $p \leq 0.01$ ) difference in varieties and packaging materials  
 222 interaction for ash content. Highest ash content was recorded by Dadaba variety which  
 223 was packaged in the jute sack and the least was Dodobi packaged in plastic drum.

**Comment [A14]:** Hematic 1<sup>st</sup>  
 Jute 2<sup>nd</sup>  
 Plastic 3<sup>rd</sup>

224 Across the varieties, Mamaba and Dadaba produced the highest ash content and the  
 225 least was Dobodi variety. With respect to the packaging materials, highest ash content  
 226 was recorded by Hematic bag and Jute sack while plastic drum produced the least. It  
 227 was observed that ash content increased in the Jute sack in the three (3) varieties of  
 228 maize, after four months of storage whilst it decreased in the Plastic drum with  
 229 fumigated maize and the Triple-layer hermetic bag, as shown in Table 3. The decrease  
 230 in ash content might have been due to the feeding activities of insect pests in the  
 231 storage materials [2].

**Comment [A15]:** No trend analysis table was shown to support this assessment

232  
 233 **Table 4: Effect of Packaging Materials on Carbohydrate Content**

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

**Comment [A16]:** Hematic 1<sup>st</sup>  
 Jute 2<sup>nd</sup>  
 Plastic 3<sup>rd</sup>

234 CV=0.96

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

237 There was significant ( $p \leq 0.01$ ) difference in varieties and packaging materials  
 238 interaction for carbohydrate content. Highest carbohydrate content was recorded by  
 239 Dadaba variety which was packaged in the hematic bag and the least was Dobidi  
 240 packaged in jute sack. Across the varieties, Dadaba produced the highest carbohydrate  
 241 content and the least was Dobidi and Mamaba varieties. The difference in carbohydrate  
 242 content could be due to the genetic differences between the varieties. In addition, the  
 243 highest carbohydrate content in the maize stored in the hematic bag could be due to the

**Comment [A17]:** Only reason attributable was genetic?

244 fact that it prevented ~~gaseous~~ exchange of gases between the maize and the storage  
 245 environment. The jute bag and plastic drum allowed exchange of gases which led to  
 246 oxidation and hydrolysis of carbohydrates in the maize, hence the low carbohydrate  
 247 content.

248

249 **Table 5: Effect of Packaging Materials on Crude Fibre Content**

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

**Comment [A18]:** If methodology does not capture crude fibre assessment where from this table

**Comment [A19]:** Jute 1<sup>st</sup>  
 Hematic 2<sup>nd</sup>  
 Plastic 3<sup>rd</sup>

250 CV=1.53

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

253 There was significant ( $p \leq 0.01$ ) difference in varieties and packaging materials  
 254 interaction for crude fibre content. Highest crude fibre was recorded by Mamaba  
 255 variety which was packaged in the jute sack and the least was Dobodi and Dadaba  
 256 packaged in hematic bag. Across the varieties, Mamaba produced the highest crude  
 257 fibre and the least was Dadaba variety. With respect to the packaging materials, highest  
 258 crude fibre was recorded by jute sack while plastic drum produced the least. Crude  
 259 fibre also saw a decrease in the Triple-layer hematic bag and the plastic drum, with an  
 260 increase in the maize stored in the Jute sack in all the three (3) varieties of maize after  
 261 four (4) months of storage as shown in tables 5. The increase might be due to the  
 262 activities of insect pests in the grains, leaving only the bran which is mostly fibre [2].

263 According to [7], the decrease in value of crude fibre content might also be due to the  
 264 emergence of holes created by weevils, since the husk of the maize grain is rich in  
 265 crude fibre.

266 **Table 6: Effect of Packaging Materials on fat**

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

**Comment [A20]:** Plastic 1<sup>st</sup>  
 Hematic 2<sup>nd</sup>  
 Jute 3<sup>rd</sup>

267 **CV=12.30**

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

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

**Comment [A21]:** Genetic reason has  
 been overused in your write up

280

281 **Table 7: Effect of Packaging Materials on Protein Content**

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

Comment [A22]: Hmatic 1<sup>st</sup>  
Jute 2<sup>nd</sup>  
Plastic 3<sup>rd</sup>

282 CV=2.24

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

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

## 296 CONCLUSION

297 Both the Triple-layer hermatic bag and the Plastic drum with treated maize were more  
298 effective in storing maize as compared to the Jute sack without any treatment given to

299 the maize stored in it. Even though there was a general reduction in the proximate  
300 composition of the stored maize at the end of the storage period, the Triple-layer  
301 hermetic bag, being air-tight, was able to conserve protein, moisture, carbohydrate and  
302 also, reduced crude fibre and ash content in the maize stored in it.

**Comment [A23]:** This conclusion is flawed, because with the exception of fat content, jute performed better than drum is all proximate analysis factors

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

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

312

### 313 **RECOMMENDATIONS**

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

315 Triple-layer hermetic bag should be used extensively in storing maize, as it has the  
316 capacity to reduced moisture loss, insect pests infestation, respiratory activities of the  
317 stored grains and also, preserving the nutritional and market value of the produce.

**Comment [A24]:** These parameters not measured

318 Finally, further study should be conducted on the storage of the three (3) varieties of  
319 maize using other methods and beyond four (4) months of storage, to ascertain the  
320 keeping quality of the maize.

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