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Impact of Storage Methods and Periods on Physical, Biological, Chemical Characters and Nutritional Value of Yellow Maize Grains

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ABSTRACT

The postharvest losses of maize grains are mainly due to storage conditions causing significant losses and lowering the product value. Parameters of storage are methods, periods, temperature, humidity and grain moisture content compromise the physico-chemical grains quality Thereupon, storage grains by the suitable method for the optimal period has become more critical to save the yield and ensuring global food security with continuing population growth. In the present study yellow maize (three -way hybrid 368) grains were stored via four storage methods (M1 -Treated threshed grains with CaCo3, M2- Threshed grains, M3- Grains on de -husk ears and M4- Covered grains with husk) and were evaluated at four storage periods (3, 6, 9 and 12 months). Results showed that maize grains stored for three months gave the highest values of biological characters (germination %, plumule length, radical length, seedling fresh weight, and seedling dry weight and by increasing storage periods caused decreasing in abovementioned traits, The same trend was applicable with chemical composition of yellow maize grains (protein%, ethereal extract %, fiber % and ash%), and nutritional value (gross energy (GE), digestible energy (DE) and total digestible nutrients (TDN) %). Data also cleared that treated threshed grains with CaCo3 (M1) gave the highest mean values of pervious traits (biological, chemical and nutritional value traits). The interaction between storage periods and storage methods had a significant impact on all abovementioned traits and P1M1 treatment gave the highest values followed by P1M2.

KEYWORDS: : Storage methods, calcium carbonate, storage periods, nutritional value, storage conditions

1. INTRODUCTION

Maize is one of the most important crops since it is produced on a large scale worldwide and Egypt as well as maize characterized with its high nutritional value and different form of use for human food and animal feed. It is also consumed as a row material for several industrial products.

Egypt production of maize is not sufficient to meet the accelerated with quantities market demand, so Egypt imports maize from exported countries. Storing maize grain effectively is pivotal in ensuring consistent maize supply and therefore avoiding major price fluctuations. All crops go through high and low price cycles. For example, the price would be at its highest just before harvest season begins, and then drop down due to the increased supply during and after harvest season. Research paid a great consideration on factors affecting storage to keep grain maize at good quality and to preserve grain nutritional value. The grain losses recorded during storage period on worldwide scale according to FAO (2020) estimation are between 5-10x of total production, in developing countries, due to reduce possibilities of implementing appropriate technologies, the wastage during storage period may increase up to 30% (Dudoiu, et al, 2016). The postharvest losses of maize grains are mainly due to storage conditions causing significant losses and lowering the product value. Parameters of storage are methods, periods, temperature, humidity and grain moisture content compromise the physico-chemical grains quality and increase the risks of quantitative and qualitative losses during storage when unsuitable storage conditions were applied. Therefor modeling of such conditions seeking balance and efficiency conditions may help to minimize grain losses. However, maize grains are easily infected via fungal attack and mostly to be contaminated with mycotoxins under unsuitable storage conditions. It was reported that an estimated value of around 25% of crop products worldwide were contaminated with various mycotoxins to different degrees (Fink - Gremmels 1999). Since traditional storage in developing countries cannot guarantee save protection to maintain maize grain quality. Absence of suitable storage facilities and storage management technology force smallholders to sell this product immediately after harvest, consequently, farmers get low market price for their products. The purpose of the storage is preservation to presence the grain quality. Therefore, storage should be researched enough for not viability loss, increase microorganism and pest attack. Many experiments were conducted to assess the efficacy of different storage methods of maize in laboratory scale. Storage method factor and its interactions with other factors like grain treatment, variety were highly significant affect grain quality (Otakgio and Akinlosotu, 2004).

Storage of maize is mainly affected by moisture content, temperature (grain and air), relative humidity, storage conditions, fungal growth and insect pests. In order to obtain high quality maize for both short-and long-term storage, maize must be protected from weather, growth of microorganisms and pests (Rashid *et al.*, 2018). Maize, like other stored products is hygroscopic in nature and tends to absorb or release moisture. Even if properly dried after harvest, exposure to moist and humid conditions during storage will cause the kernel to absorb water from the surroundings (Devereau *et al.*, 2002), leading to increased grain moisture contents, which results in enhanced deterioration. Therefore, grain maize growers are usually confronted with difficulty in the safe storage of their grain yield because of high moisture content at the time of harvest. when chemical components of the grain were monitored after harvest and during drying, no effect of drying temperature were found on organic matter, dry matter crude protein, neutral detergent fiber, acid detergent fiber and gross energy (Quanfeng et al ,. 2014) Concern was paid to the effect of different type of storage on nutritional quality of maize, whereas investigation revealed that dry matter, crude protein, crude fat, crude fiber, crude ash and metabolizable energy affected due to supplying difficult types of storage. Traditional formers do seeds storage simply by putting it on the floor of their home without a specific treatment, research was arranged to store seeds in room temperature with an open packaging condition. Parameter observations conducted on moisture content of seed, 1000 grain weight, electrical conductivity, germination, growth rate, primer root length and shoot length. Seed that had long been stored in storage shed and small seed weight would accelerate the decline of physiological seed quality, respectively growth the rate and percentage of germination. Storage of seeds in an open package of room temperature could maintain quality of the seeds up to 3 months with large grain weight on the varieties and the low water content of the initial storage (Suwarti and Aqil, 2019). After eight months storage in the "uncontrolled" warehouse, the germination declined to 50-80% (Tekrony et al., 2005). Germination and vigor tests information can be used to make informed decisions regarding the value of different seed lots (Copeland and McDonald, 2001; Tekrony, 2003; ISTA, 2006). Maize stored in ambient conditions must be close to 13% moisture content to maintain its shelf life and minimize damage due to mold spoilage and insect damage. Damage levels of maize not managed properly in open storage can be easily exceeding 30% to 40% .

Insect, rodent and molds were the main storage problems reported by farmers. Researches repeated that storage losses were highest in the moist transitional and moist mid-altitude zones, and the lowest in the dry zones. Overall, rodent represented the second most important cause of storage losses after insects. Where maize was stored in cobs, total farmer perceived (farmer estimation) storage weight losses were 11.1±0.7%, with rodents causing up to 43% of these losses. Contrastingly, where maize was stored at shelled grain, the losses were 15.5±0.6% with rodents accounting for up t0 30% (Ognakassom et al., 2016) .

The aim of this study is to evaluate different storage methods and different storage periods for yellow grain maize and their effect on grain quality to find out the appropriate storage method and period to maintain seed quality for ordinary former and small holders with limited storage facilities.

2. MATERIALS AND METHODS

Experiments were carried out at Agronomy Seeds lab and Crop Physiology lab Agronomy Dept., faculty of Agriculture, Ain shams university. The present investigation was proposed to evaluate the effects of different storage methods at several storage periods on quality and nutrient value of yellow grain maize (Zea mays L.). In Egypt, maximum storage periods for yellow grain maize is a whole year before the release of new maize production in the market, therefore, this investigation was proposed to store grains at maximum period of a whole year for monitoring changes on grain quality and fodder nutritional value at fixed intervals through the year as kept by different methods.

2.1.Seed Material

Newly harvest yellow grain maize was submitted from Field Crop Institute, Agricultural Research Center (ARC), production of 2020, Due to Covid 19 pandemic, universities were shut down as a precaution procedure to control Covid 19 pandemic. Experiments were repeated it newly harvested yellow grain maize submitted from the same source, production of 2021. Grains of (three -way hybrid 368) at moisture content of 13%were harvested manually and air dried for both grains on ears and separated grains.

2.2.Treatments:

grains yellow maize were subjected to four different storage methods at different storage periods as follow:

2.2.1. Storage methods:

M1 -Treated threshed grains (TTG)

Grains were detected from the cob manually after air dried till the grains reached moisture content of 13%. Grains were threshed and mixed thoroughly with calcium carbonate ($CaCo_3$) at rate of 1 g/ 100 g seed.

M2- Threshed grains (TG)

Grains were detected from the cob manually after air dried till the grains reached moisture content of 13%. Grains were threshed and stored at paper bags on room temperature in Agronomy Seed lab.

M3- Grains on de -husk ears (GDH)

Ears husk were removed, and grain remained on cab after air dried till the grains reached moisture content of 13%. De-husk ears were stored at paper bags on room temperature in Agronomy Seed Lab.

M4- Covered grains with husk (CGWH).

Grains were submitted on its ear; this group was air dried till the grains reached moisture content of 13% covered ears with husk were stored on paper bags on room temperature in Agronomy Seed Lab.

2.2.2. Storag periods:

Grains of the four storage methods were storage at room temperature in Agronomy Seed Lab. At four different storage periods which were the following:

A-Three months
B-Six months
C-Nine months
D-Twelve months

Conditions of Storage:

Storage conditions at the Laboratory where the experiment carried out were mentioned from the first day to the end day of the experimental.

The most import factors were recoded which were room temperature and relative humidity**.** Room temperature ranged between 20 ºC and 29 ºC, and relative humidity (RH) ranged between 63 % and 84 % for the storage periods mentioned above. Changes of temperature and RH. through storage periods were demonstrated in Fig.1.

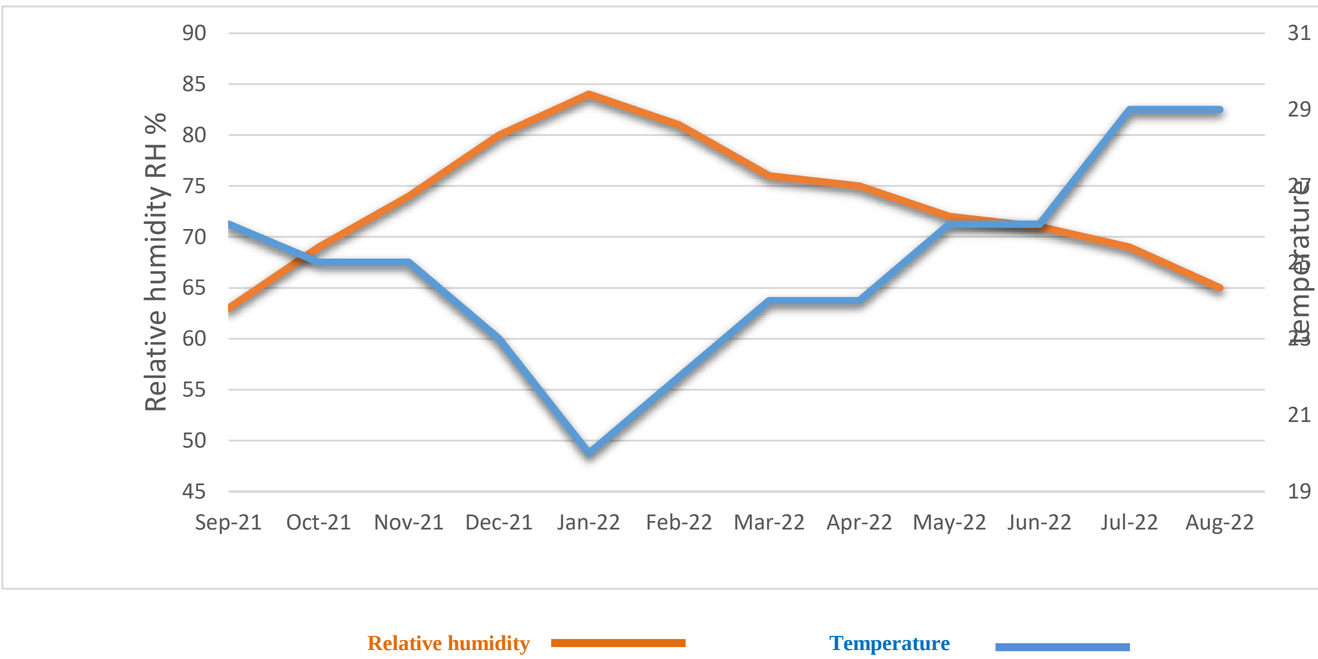


Fig 1. changes of temperature and relative humidity (RH) of Agronomy Seed lab for the storage periods of four different storage methods under investigation

Grain moisture content determination:

Moisture content of grains was measured by using on electric meter that uses electrical characteristics of the grain.
Electronic Moisture meter Model Gann Hydrometer G86 instrument was used to determine grain moisture as described in operation manual.

2.3.Characters Studied

2.3.1. Physical characters:

A-Weight of 100 grains (g)

One hundred grains obtained from each treatment and countered at four replicates and weighted by a balance of two decimal digit accuracy.

B-Grains specific weight (g/cm^3)

Grains of a unit volume (1000 cm^3) were weighted and calculated using the following equation according to **(ISTA, 1996)**

$$\text{Grain specific weight} = \frac{\text{Grains of unit volume weight (g)}}{\text{Volume (cm}^3\text{)}}$$

2.3.2. Biological characters:

Germination test

Germination testwas carried out according to the guide of international roles for seed testing ‘published. By "The International Seed Testing Association “(ISTA, 1996). Four replicates of 100 grains each were planted in pots contains sterilized sand. The grains were placed uniformly at same depth on the sord, the germination test was performed in incubation at 25 ºC and the following parameters were reached.

A-Germination percentage (G%)

G%= (t/T) x 100

Where

t: is the number of germinated seed

T: is the number of seed used for germination test.

2.3.3. Chemical Characters:

About 50g of grains were fine grinding to determine nitrogen percentage (N%) using micro-Kjeldal method according to AOAC (1995). The crude protein content of grains (GCPC) was calculated by multiplying total N% by 5.7. Crude fat was extracted with petroleum ether (boiling range of 40–60°C) by the Soxhlet extraction method. Crude ash was determined by incineration in a muffle furnace at 550°C for 3 h (Commission Regulation (EC) No. 152/2009). Crude fiber was determined as the residue after sequential treatment with hot H_2 SO_4 (conc. 1.25%) and hot NaOH (1.25%) according to AOAC (1995). Nitrogen-free extract (NFE) was calculated as follows: NFE (%) = 100 − (moisture % + crude protein % + crude fat % + crude ash % + crude fibre %) (Serna-Saldivar, 2012).

2.3.4. Grain nutritional value:

The calculated feeding values were calculated according to the following calculation: -

GE = (CP*4) + (Cf*4) + (NFE* 4) + (EE*9), according to Blaxter (1966).

GE: Gross energy, CP: crude protein, CF: crude fiber, EE: ethereal extract, NFE : Nitrogen-free extract

DE = GE x 0.76, according to NRC (1988).

TDN= DE / 4.409 x 100 according Crampton et al., 1957 and Swift, 1957.

2.4.Statistical Analysis:

Completely random design was applied with four replicates; where, treatments were distributed randomly. All the obtained data were exposed to proper statistical analysis according to Snedecar and Cachran 1991), For means comparison, all data were subjected to analysis of variance by Duncan multiple range test (Duncan, 1955).

3. RESULTS AND DISCUSSION

3.1.Germination and seedling traits

Based on the analysis of variance (ANOVA), the data as presented in Table (1) showed the effects of storage period (3, 6, 9 and 12 months, coded as P1, P2, P3, and P4, respectively) and four different storage methods (Treated threshed grains with $CaCo_3$ (TTG), Threshed grains (TG), Grains on de-husk ears (GDH) and covered grains with husk (CGWH)) on the germination, plumule length (cm), radical length (cm), seedling fresh weight (g), and seedling dry weight (g) of yellow maize grains. The results revealed that the storage period and method had a significant effect on the germination, plumule length, radical length, seedling fresh weight, and seedling dry weight of yellow maize grains. Regarding storage periods, germination percentage decreased with increasing storage periods but was highest for 3 months; and the length of the plumule and radical length were decreased as the storage period increased but were highest values for 6 and 3 months, respectively. Also, the fresh and dry weight of seedlings decreased as the storage period increased, then grains stored for 6 and 3 months were recorded the highest values respectively. It was shown that germination after storage decreased with length of storage, this occurred because most of the stored seed were infected with fungi although seeds were stored at acceptable temperature (10°c) there were lowered germination percentage (Gilbert *et al.*, 1997). In addition *(*Tekrony *et al., 2005)* found that after eight months storage in the uncontrolled warehouse, the germination declined to 50-80%.

Concerning the storage methods, the results showed that germination %, plumule length (cm), radical length (cm), seedling fresh

Table 1. Effect of storage periods and methods of yellow maize grains on germination percentage and seedling traits.

Treatment	Germination %	plumule length (cm)	Radical length (cm)	Seedling fresh weight (g)	Seedling dry weight (g)
3 months (P1)	97.38 a	22.27 b	19.09 a	1.03 b	0.67 a
6 months (P2)	82.13 b	29.37 a	17.93 a	1.32 a	0.16 b
9 months (P3)	77.94 c	22.71 b	14.52 b	0.99 b	0.22 b
12 months (P4)	35.25 d	15.59 c	7.66 c	0.74 c	0.24 b
TTG (M1)	98.63 a	29.65 a	18.05 a	1.46 a	0.49 a
TG (M2)	79.00 b	27.57 b	16.62 a	1.32 a	0.29 b
GDH (M3)	60.25 c	17.35 c	13.16 b	0.72 b	0.23 b
CGWH (M4)	54.81 d	15.38 c	11.36 b	0.59 b	0.26 b
Interaction between periods and storage methods					
P1M1	100.00 a	23.78 def	16.44 abcd	1.14 cd	0.84 a
P1M2	96.25 a	21.69 ef	20.02 ab	0.94 d	0.68 a
P1M3	96.75 a	21.74 ef	20.14 ab	1.00 cd	0.49 b
P1M4	96.50 a	21.88 ef	19.75 ab	1.07 cd	0.67 a
P2M1	100.00 a	32.00 ab	20.81 a	1.40 bc	0.18 cd
P2M2	87.50 bc	31.63 ab	15.78 bcd	1.65 ab	0.17 cd
P2M3	74.50 d	27.59 bcd	19.38 abc	1.12 cd	0.12 cd
P2M4	66.50 d	26.28 cd	15.76 bcd	1.12 cd	0.15 cd
P3M1	99.50 a	32.31 a	19.94 ab	1.90 a	0.18 cd
P3M2	86.25 c	25.10 de	15.06 cd	1.11 cd	0.14 cd
P3M3	69.75 d	20.06 f	13.13 de	0.77 d	0.32 bc
P3M4	56.25 e	13.38 g	9.94 e	0.18 e	0.23 c
P4M1	95.00 ab	30.50 abc	15.03 cd	1.39 bc	0.77 a
P4M2	46.00 f	31.88 ab	15.63 bcd	1.57 ab	0.17 cd
P4M3	0.00 g	0.00 h	0.00 f	0.00 e	0.00 d
P4M4	0.00 g	0.00 h	0.00 f	0.00 e	0.00 d

M1 :Treated threshed grains with $CaCo_3$ (TTG) P1: storage for 3 months
M2: Threshed grains (TG) P2: storage for 6 months
M3: Grains on de -husk ears (GDH) P3: storage for 9 months
M4: Covered grains with husk (CGWH) P4: storage for 12 months

weight (g), and seedling dry weight (g) were highest for treated threshed grains with CaCO3 (TTG) and lowest for covered grains with husk (CGWH) and grains on de-husk ears (GDH), respectively. This result may be due to calcium carbonate absorbs moisture from the surrounding atmosphere, which preserves the integrity of the grain, as well as reducing the chances of infection with store pests, which leads to preserving the grain for a longer period.

The interaction between storage period and storage method had a significant impact on all abovementioned traits. Germination percentage was highest for grains stored for 3 months (P1) under four different storage methods (TTG, TG, GDH and CGWH) with non-significant difference. However, storage period for P2, P3 and P4 had the highest values with non-significant differences under TTG treatment. plumule length (cm) had the highest values with non-significant difference under P3M1, P2M1, P4M2, P2M2 and P4M1. Radical length was highest for grains stored for P1 under four different storage methods (TTG, TG, GDH and CGWH) with non-significant difference. Seedling fresh weight had the highest values with non-significant difference under P3M1, P2M2 and P4M2. seedling dry weight had the highest values with non-significant difference under P1M1, P4M1, P1M2 and P1M4. In brief, maize grains were stored for 3, 6, 9 and

12 months under two storage methods i.e., Treated threshed grains with CaCo3 (TTG) followed by Threshed grains (TG). TTG method is the most effective way to store maize grains to reserve its quality. The TG method is also effective, but not as effective as the TTG method. The GDH and CGWH methods are less effective than the TG method.

3.2. Weight of 100 grain, insect%, hectoliters and moisture content

The results of the study as presented in Table 2 had showed effects of storage periods (P1, P2, P3, and P4) and four different storage methods (TTG, TG, GDH and CGWH) on weight of 100-grains, insect percentage, hectoliters and moisture percentage of yellow maize grains. The data shows that the weight of the grain, the percentage of insects, the hectoliters, and the moisture percentage had significantly changed over time and depending on the storage method.

Concerning the storage periods; it has been found that P1 and P2 had given the highest values with non-significant difference for weight of 100-grains and hectoliters. Also the same period gave the lowest values for insect percentage and moisture percentage. About storage methods, the TTG followed the TG had shown the maximum values for weight of 100-grains and hectoliters, also had revealed the minimum values for insect percentage and moisture percentage.

Table 2. Effect of storage periods and methods on 100 grain weight, insect%, Hectoliters and moisture content of yellow maize grains

Treatments	100 grain weight (g)	Insect %	Hectoliters	Moisture %
3 months (P1)	33.46 a	1.56 c	868.1 a	10.63 d
6 months (P2)	33.50 a	5.50 c	857.0 a	11.08 c
9 months (P3)	26.44 b	46.44 b	813.9 b	11.96 b
12 months (P4)	26.38 b	58.69 a	751.5 c	12.99 a
TTG (M1)	37.63 a	1.38 d	904.1 a	10.99 d
TG (M2)	33.88 b	16.06 c	891.1 a	11.44 c
GDH (M3)	25.13 c	44.31 b	746.6 b	11.92 b
CGWH (M4)	23.14 d	50.44 a	748.8 b	12.31 a
Interaction between periods and storage methods				
P1M1	38.50 a	0.25 f	1036.5 a	10.38 j
P1M2	33.00 c	1.00 f	909.0 b	10.46 j
P1M3	31.25 c	3.00 ef	790.0 de	10.73 hi
P1M4	31.08 c	2.00 f	737.0 ef	10.93 gh
P2M1	37.75 a	0.50 f	843.0 bcd	10.53 ij
P2M2	33.75 bc	2.50 f	869.0 b	10.97 g
P2M3	31.50 c	7.50 ef	853.0 bcd	11.34 f
P2M4	31.00 c	11.50 e	863.0 bc	11.48 ef
P3M1	37.00 a	1.75 f	865.9 bc	11.03 g
P3M2	33.00 c	20.25 d	879.5 b	11.57 e
P3M3	20.50 d	73.75 b	800.2 cd	12.67 c
P3M4	15.25 e	90.00 a	710.1 fe	12.57 c
P4M1	37.25 a	3.00 ef	871.0 b	12.03 d
P4M2	35.75 ab	40.50 c	907.0 b	12.73 bc
P4M3	17.25 e	93.00 a	543.0 g	12.93 b
P4M4	15.25 e	98.25 a	685.0 f	14.26 a

M1 :Treated threshed grains with $CaCo_3$ (TTG)
M2: Threshed grains (TG)
M3: Grains on de -husk ears (GDH)
M4: Covered grains with husk (CGWH)

P1: storage for 3 months
P2: storage for 6 months
P3: storage for 9 months
P4: storage for 12 months

Overall, the grain weight had decreased over time, the insects % had increased over time, the hectoliters had decreased over time, and the moisture % had increased over time. The storage method also had a significant effect on the abovementioned traits, and the TTG followed the TG were the best storage methods.

The interaction between storage periods and storage methods also influenced the quality of maize grains. Data result as presented in Table 2 had revealed that P1M1, P2M1, P4M1, P3M1 and P4M2 had given the highest values of weight of 100-grains. Regarding insects %, it is found that P1M1, P2M1, P4M1, P3M1 and P4M2 had given the minimum values. The P1M1 followed by P1M2, P4M2 and P4M1had shown the maximum values of hectoliters. Finally, the interaction between P1M1, P1M2 and P2M1had resulted the minimum values for moisture percentage. At few words, The TTG followed by TG method were the most effective storage treatments. Similar results were obtained by (Ognakasson *et al*., 2016), they found that maize stored in ambient conditions must be close to 13% moisture content to maintain its shelf life and minimize damage due to mold spoilage and insect damage. Damage levels of maize not managed properly in open storage can be easily exceed 30% to 40%. Insect, rodent and molds were the main storage problems reported by farmers. Researches repeated that storage losses were highest in the moist transitional and moist mid-altitude zones, and the lowest in the dry tramxtional zones. Overall, rodent represented the second most important cause of storage losses after insects. Where maize was stored in cobs, total farmer perceived (farmer estimation) storage weight losses were 11.1±0.7%, with rodents causing up to 43% of these losses. Contrastingly, where maize was stored at shelled grain, the losses were 15.5±0.6% with rodents accounting for up to 30%

3.3.Chemical composition of grains

Data in table 3 shows the effect of storage periods (3, 6, 9 and 12 months) , storage methods (treated threshed grains with $CaCo_3$ (TTG), threshed grains (TG), grains on de -husk ears (GDH) and covered grains with husk (CGWH)) and their interaction on chemical composition of yellow maize grains (protein%, ethereal extract %, fiber %, ash% and NEF%). Results showed a significant effect of storage periods on yellow maize grain chemical composition and the storage treatment for 3 months recorded the highest values for the following studied traits i.e., protein%, ethereal extract %, fiber % and ash%. On the other hand the highest value of NEF percentage was recorded at storage period 12 months. Results also cleared that by prolonging the storage period from 3 months to 6, 9 and 12 months, this led to a significant decrease in all the previous characteristics except NEF percentage. In addition, the percentage of decrease was estimated when storing for a period of 12 months compared to storage for a period of 3 months as follows protein 26.26%, ethereal extract 31 %, fiber 26.79% and ash 14.96%. In respect of the effect of storage methods on quality of yellow maize grains data in table 3 shows that there was a significant effect and the grains were treated with calcium carbonate recorded the highest values of protein%, ethereal extract %, fiber % and ash% thus, it is considered the most appropriate storage method that preserves the value of grains. In the same time this treatment (TTG) recorded the lowest value of NEF percentage. On the other hand, covered grains with husk (CGWH) gave the lowest main values of protein%, ethereal extract %, fiber % and ash% it means that there was an inverse relationship between NEF and the other grain measured components.

The interaction between storage period and storage method had a significant impact on abovementioned traits as well as data presented in Table 3 had revealed that P1M1, P1M2, P1M3, P1M4, P2M1 and P2M2 had given the highest values of protein % and fiber % followed by P2M3 and P3M1 for protein only. This result means that maize grains treated with calcium carbonate were less susceptible to protein deterioration with increasing storage period from 3 to 9 months. Concerning the effect of interaction between periods and storage methods on ethereal extract and ash % data revealed that P1M1 and P1M4 treatments gave the highest mean values respectively. The results also showed that covered grains with husk (CGWH) were stored for 12

Table 3. Effect of storage periods and methods on Chemical composition of yellow maize grains.

Treatments	Protein %	Ethereal extract %	Fiber %	Ash %	Nitrogen-free extract (NFE %)
3 months (P1)	10.32 a	3.71 a	3.21 a	1.47 a	81.29 d
6 months (P2)	9.95 b	3.40 b	3.03 b	1.42 b	82.20 c
9 months (P3)	8.88 c	2.97 c	2.80 c	1.37 c	83.98 b
12 months (P4)	7.61 d	2.56 d	2.35 d	1.25 d	86.23 a
TTG (M1)	9.75 a	3.48 a	3.01 a	1.41 a	82.35 d
TG (M2)	9.38 b	3.25 b	2.87 b	1.38 ab	83.13 c
GDH (M3)	9.18 c	3.02 c	2.77 c	1.35 b	83.68 b
CGWH (M4)	8.47 d	2.89 d	2.75 d	1.36 b	84.54 a
Interaction between periods and storage methods					
P1M1	10.53 a	3.84 a	3.26 a	1.45 b	80.92 m
P1M2	10.39 a	3.77 b	3.22 ab	1.43 b	81.19 l
P1M3	10.24 a	3.68 c	3.18 abc	1.43 b	81.47 k
P1M4	10.12 a	3.55 d	3.17 abc	1.57 a	81.59 jk
P2M1	10.46 a	3.67 c	3.19 abc	1.44 b	81.23 l
P2M2	10.26 a	3.54 d	3.03 abcd	1.44 b	81.73 j
P2M3	9.88 ab	3.24 f	2.93 cde	1.41 bc	82.54 i
P2M4	9.22 bc	3.15 g	2.98 bcde	1.37 bcd	83.28 h
P3M1	9.78 abc	3.36 e	2.94 cde	1.42 bc	82.5 i
P3M2	9.03 bcd	3.03 h	2.87 def	1.36 bcd	83.71 g
P3M3	8.95 cd	2.83 i	2.73 ef	1.37 bcd	84.12 f
P3M4	7.78 e	2.64 j	2.67 f	1.33 cd	85.57 d
P4M1	8.23 de	3.03 h	2.67 f	1.33 cd	82.50 i
P4M2	7.84 e	2.65 j	2.34 g	1.30 d	85.87 c
P4M3	7.65 e	2.35 k	2.22 g	1.19 e	86.59 b
P4M4	6.74 f	2.22 l	2.17 g	1.16 e	87.71 a

M1: Treated threshed grains with $CaCo_3$ (TTG) P1: storage for 3 months
M2: Threshed grains (TG) P2: storage for 6 months
M3: Grains on de -husk ears (GDH) P3: storage for 9 months
M4: Covered grains with husk (CGWH) P4: storage for 12 months

months, while achieving the lowest values of protein%, ethereal extract %, fiber % and ash% also gave the highest value for NEF percentage.

3.4.Grain nutritional value

The results as presented in Table 4 had showed significant effects of storage periods (P1, P2, P3, and P4) and four different storage methods (TTG, TG, GDH and CGWH) and their interactions on nutritional value (gross energy (GE), digestible energy (DE) and total digestible nutrients (TDN) %) of yellow maize grains. The data shows that the abovementioned traits had significantly changed and decreased by prolonging the storage periods as well as the highest and the lowest values of GE, DE and TDN were recorded with storage periods of 3 and 12 months, respectively. Results also clarified that treated threshed grains with CaCo3 (TTG) was the most suitable storage method to save the nutritional value of grain and recorded the highest values of gross energy (GE), digestible energy (DE) and total digestible nutrients (TDN) %. While storage covered grains with husk (CGWH) gave the lowest values of the pervious traits. In respect to the impact of interaction between periods and method of storage on gross energy (GE), digestible energy (DE) and total digestible nutrients (TDN) % of yellow maize grains, data cleared that P1M1 gave the highest values followed by P1M2 for the

Table 4. Effect of storage periods and methods on nutritional value of yellow maize grains

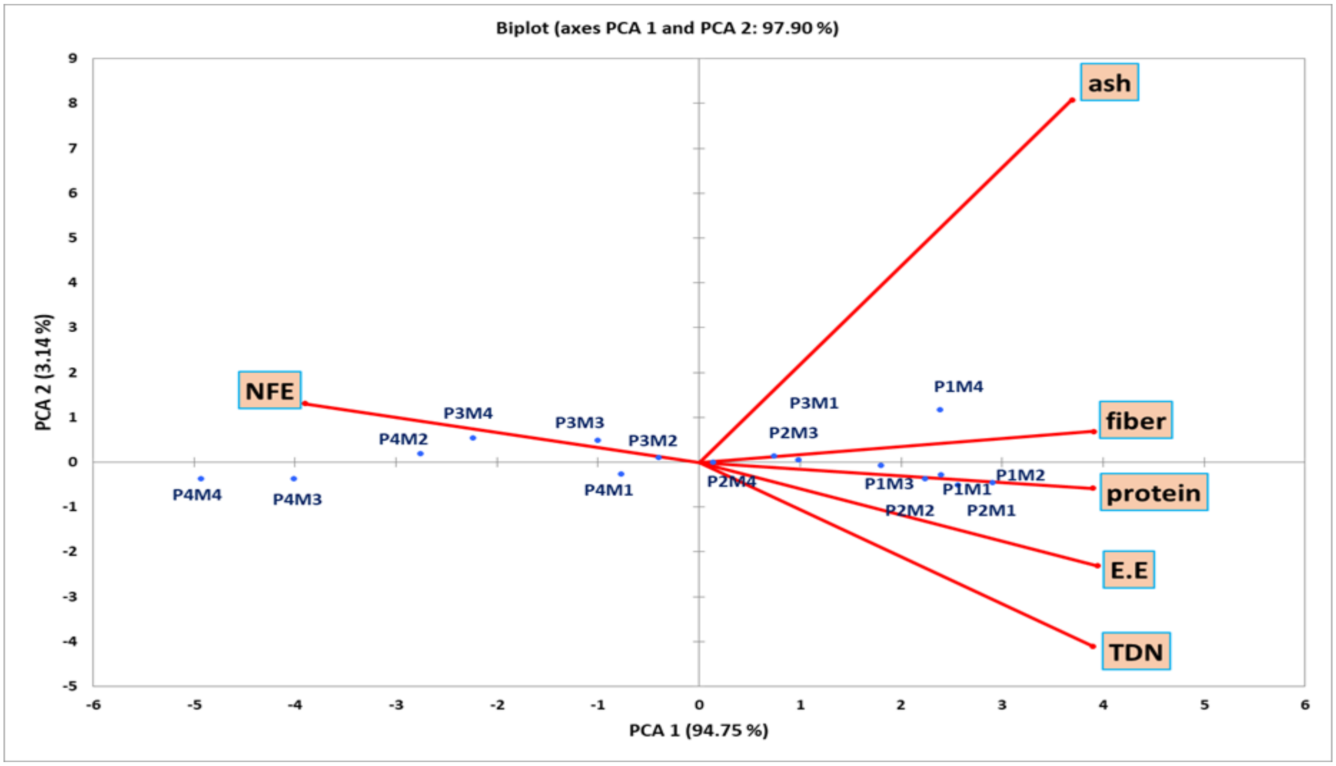
Treatments	Gross Energy (GE)	Digestible Energy (DE)	Total Digestible Nutrients % (TDN)
3 months (P1)	412 a	313 a	71.13 a
6 months (P2)	411 b	312 b	70.90 b
9 months (P3)	409 c	311 c	70.56 c
12 months (P4)	407 d	309 d	70.30 d
TTG (M1)	411 a	313 a	70.97 a
TG (M2)	410 b	312 b	70.79 b
GDH (M3)	409 c	311 c	70.62 c
CGWH (M4)	409 d	310 d	70.50 d
Interaction between periods and storage methods			
P1M1	413 a	314.2 a	71.26a
P1M2	413 ab	313.96 ab	71.21ab
P1M3	413 b	313.61 b	71.13b
P1M4	411 cd	312.73cd	70.93cd
P2M1	413 b	313.56b	71.12b
P2M2	412 c	313.06c	71.01c
P2M3	411 e	312.03e	70.77e
P2M4	410 ef	311.8ef	70.72ef
P3M1	411 d	312.47d	70.87d
P3M2	410 g	311.36g	70.62g
P3M3	409 h	310.59h	70.44h
P3M4	408 i	309.98i	70.31i
P4M1	410 fg	311.47fg	70.64fg
P4M2	408 i	310.13i	70.34i
P4M3	407 j	309.3j	70.15j
P4M4	406 k	308.92k	70.07k

M1: Treated threshed grains with CaCo3 (TTG) P1: storage for 3 months
M2: Threshed grains (TG) P2: storage for 6 months
M3: Grains on de -husk ears (GDH) P3: storage for 9 months
M4: Covered grains with husk (CGWH) P4: storage for 12 months

abovementioned traits, while storage covered grains with husk (CGWH) for 12 months (p4M4) recorded the lowest nutritional value of grains. It is noting that treatment 1 recorded the lowest rates of deterioration in the nutritional value of grains with prolonged storage period.

3.5.Relationship between the evaluated chemical parameters and treatments

The relationship between the evaluated chemical composition of yellow maize grains and treatments was investigated using principal component analysis, as shown in Figure 2. The variability was illustrated by the first two PCAs at 97.90%. The PCA1 possessed for 94.75% of the variation and was associated with the assessed treatments of methods (M) and periods (P) storage. The PC1 divided the storage periods into two groups; the storage period of three months and six months with all the studied storage methods were located on the positive side, but those of nine months and twelve months storage with all the studied storage methods were located on the negative side. All chemical composition of grains (i.e. protein %, ethereal extract % (E.E), Fiber %, and Ash %) and total digestible nutrients (TDN) were positively correlated with the storage period of three months and six months with all the studied storage methods on the positive side of PC1. While nitrogen free extract (NFE %) was positively associated with prolonging storage periods up to nine months and twelve months while negatively with storage period of three months and six months (Fig 2).



NFE : Nitrogen-free extract   TDN: Total Digestible Nutrients %   EE: Ethereal extract

Fig 2. Principal component analysis biplot for the evaluated chemical composition of yellow maize grains based on treatments storage methods (M) and periods (P).

4. REFERENCES

AOAC (1995). Official Methods of Analysis of The Association of Official Analytical Chemists. Washington, DC USA.

Blaxter JHS (1966). The effect of light intensity on the feeding ecology of herring. The British Ecological Society Symp, Vol 6. Blackwell Scientific Publications, Oxford, p 393-409

Copeland LO and McDonald MB (2001). Principles of Seed Science and Technology, 4th ed. Kluwer Academic Publishers,Massachusetts, pp. 124–128.

Crampton EW, Lloyd LE and Mackay VG (1957). The calorie value of TDN. J. of Anim. Sci. 16: 541-545

Devereau AD, Myhara R and Anderson C (2002). Physical factors in post-harvest quality. Crop Post-Harvest: Science and Technology: Principles and Practice, Volume 1. Chapter 3: 62-92.

Dudoiu R, Cristfa S, Lupu C, Popa D and Oprea M (2016). Micoflora associated with maize grains during storage period." Agrolife Scientific Journal 5(1): 63-58.

Gilbert J, Tekauz A and Woods SM (1997). Effect of storage on viability of Fusarium head blight-affected spring wheat seed Plant Disease, 81, pp. 159-162

International Seed Testing Association (ISTA) (2006). International rules for seed testing. Seed Science and Technology. Basserdorf, Switzerland.

National Research Council. (1988). Nutrient requirements of swine. 9th rev. ed. National Research Council, National Academy Press, Washington, DC. 93 pp.

Ognakossan KE, Affognon HD, Mutungi CM, Sila DN, Midingoyi SG and Owino WO (2016). "On-farm maize storage systems and rodent postharvest losses in six maize growing agro-ecological zones of Kenya." Food Security 8: 1169-1189.

Quanfeng L, Meng S, Chuanxin S, Dewen L, Xiangshu P, Defa L and changhua L (2014). Effect of variety and drying method on the nutritive value of maize for growing pigs. J. of anim. Sci. and biotech. 5: 1-7.

Suwarti SR and Aqil M (2019). Maize seed quality evaluation at the temperature room storage with open package condition. AGRIVITA, J. of Agric. Sci.: 482-490.

Serna-Saldivar SO (2012). Laboratory reference and procedures manual. New York, USA, 368 p.

Tekrony DM (2003). Review: precision is an essential component of seed vigor testing. Seed Science and Technology 31, 435–447.

Tekrony DM, Shande T, Rucker M and Egli DB (2005). Effect of seed shape on maize germination and vigour during warehouse and controlled environmental storage. Seed Science and Technology 33, 185–197.

الملخص العربي

تأثير طرق و فترات التخزين علي الصفات الطبيعية و البيولوجية و الكيميائية و القيمة الغذائية لحبوب الذرة الصفراء

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تعود خسائر ما بعد الحصاد لحبوب الذرة بشكل رئيسي إلى ظروف التخزين التي تسبب خسائر كبيرة وخفض جودة المنتج. و العوامل المؤثرة علي التخزين هي طرق وفترات التخزين، درجة الحرارة، الرطوبة وزيادة محتوى رطوبة الحبوب يضر بجودة الحبوب الطبيعية والكيميائية وبالتالي أصبح تخزين الحبوب بالطريقة المناسبة و الفترة المثلى أكثر أهمية لحفظ المحصول وضمان الأمن الغذائي العالمي مع استمرار الزيادة السكانية. في هذه الدراسة تم تخزين حبوب الذرة الصفراء (هجين ثلاثي ٣٦٨) بأربع طرق تخزين (M1– الحبوب المفرطة مخلوطة مع كربونات الكالسيوم CaCo3، M2– الحبوب المفرطة ، M3– الحبوب على الكيزان مع ازالة اغلفة الكوز ، M4– الحبوب علي الكيزان مع وجود اغلفة الكوز) وتم تخزينها علي أربع فترات تخزين (٣ و ٦ و ٩ و ١٢ شهرًا). أظهرت النتائج أن حبوب الذرة المخزنة لمدة ثلاثة أشهر أعطت أعلى قيم للصفات البيولوجية (نسبة الإنبات ، طول الريشة ، طول الجذير ، الوزن الغض للبادرة ، الوزن الجاف للبادرة ، وبزيادة فترات التخزين أدى إلى تناقص الصفات السابقة ، وأظهرت النتائج نفس الاتجاه مع التركيب الكيميائي لحبوب الذرة الصفراء (٪ بروتين ، مستخلص أثيري٪ ، ألياف٪ ورماد٪) ، والقيمة الغذائية (إجمالي الطاقة (GE) ، طاقة قابلة للهضم (DE) وإجمالي العناصر الغذائية القابلة للهضم (TDN)٪). كما أن الحبوب المعاملة بكربونات الكالسيوم أعطت أعلى متوسط قيم للصفات السابقة (الصفات البيولوجية والكيميائية والغذائية) ، وكان للتفاعل بين فترات التخزين وطرق التخزين تأثير معنوي على جميع الصفات المذكورة أعلاه وأعطت معاملة P1M1 (الحبوب المعاملة بكربونات الكالسيوم و تخزين لمدة ٣ اشهر) أعلى القيم تليها P1M2 (الحبوب المفرطة وتخزين لمدة ٣ اشهر)

الكلمات المفتاحية: طرق التخزين، كربونات الكالسيوم، فترات التخزين، القيمة الغذائية و ظروف التخزين