Comparative analysis of the effect of hermetic storage models on some quality parameters of soybean seeds

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Abstract: The comparative analysis of the effect of hermetic storage models on some quality parameters of soybean seeds was studied. Freshly harvested soybean pods were depodded and the seeds were sundried at 33°C with an average relative humidity of 62% for three days. The seeds were then divided into three portions of 400 g and each portion was put into different storage models which were PVC bags of 400 g, jars of 1 L capacity and another jar (perforated) of 1 L capacity which served as the control. The initial quality parameters of the soybean seeds were determined, while the storage models and control were kept for eight weeks. Samples in each storage model and control were analyzed for proximate composition and other quality parameters at the end of every two weeks. The data obtained were analyzed statistically to determine the effect of hermetic storage models on the nutritional properties together with some quality parameter such as dry matter and hectolitre weight of the stored soybean seeds. Results for the nutritional properties showed that the raw soybean seeds consisted of 8.36% moisture, 15.23% fat, 6.12% ash, 5.18% fibre, 44.18% protein and 20.94% carbohydrate. The values for dry matter and hectolitre weight were 91.63% and 72.30 hl kg^{-1} respectively. The moisture content, carbohydrate and hectolitre weight of the soybean seeds increased significantly (P<0.05) in the control, while crude fat, crude fibre, ash content, crude protein and dry matter decreased. For that of the bag and jar, the carbohydrate, hectolitre weight and the dry matter of the soybean seeds increased significantly (P<0.05) while the crude fibre, fat, ash, crude protein and moisture content decreased. Thus, the hermetic storage models had effect on some of the nutritional parameters of the stored soya bean samples.

Keywords: soybean, hermetic, storage, hectoliter weight, proximate composition

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1 Introduction

Soybean (*Glycine max*) is a leguminous vegetable of the pea family with high protein content (40%) and high-quality oil (20%) (Osho, 2003).

It is believed that soybean has been part of the history of China for about 5,000 years, but now the production of soybean is circulating to different parts of the world (Ugwu and Nwoke, 2011).

Soybean is one of the most valuable crops in the world. It is not only as an oil seed grains and feed for aquaculture and livestock, but also as a good source of protein for the human food and as a bio-fuel feedstock (Masuda and Goldsmith, 2009). It is an annual herbaceous plant which is erect, bushy and with leafy plant structure. The plant was categorized as an oil-seed rather than a pulse by the Food and Agricultural Organization (FAO, 2003). Soybean seeds were first introduced into Nigeria in 1908, but were successfully cultivated in 1973 using Malayan variety, which was found to be suitable for industrial production in Benue state (Fennel, 1966).

Storage is a vital stage of the postharvest system. According to FAO (2002), during this stage, the soybeans are kept in such a way as to guarantee soybean availability other than during periods of its agricultural production and conserve its potential quality as lengthy as possible. The main objectives of soybean storage are to

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permit soybean use throughout the year, to guarantee seed availability for the next planting season, to ensure consistent and continuous supplies of raw soybeans for processing industries and to balance the demand and supply of soybean, thereby stabilizing its market value.

According to Monira et al. (2012), soybean seeds lose viability within 3-4 months if the storage arrangement and the condition of seed are improper. High temperature, relative humidity and moisture in the storage environment appear to be principle causes of deterioration of seed quality. The type of container used in storage also has the ability to regulate temperature, relative humidity and seed moisture contents. Maintenance of seed quality during storage period is important not only for crop production in the following year but also for the maintenance integrity of the seeds. Some of the storage methods available do not provide the necessary atmospheric condition required in sustaining the quality of the grain. Many grains including soybeans are been preserved using chemicals which are hazardous to human health and environment. The need for storing grain in its natural form without losing quality or with no significant lose can only be achieved by atmospheric manipulation of the environment where the grain will be stored, and this can only be achieved from hermetic storage system.

Hermetic storage is an ancient technology used to control insect infestation in grains and to preserve its nutrient quality and caloric value. In ancient times, agricultural communities stored their excess grains in structures or containers that kept the grains safe from the elements and limited the entrance of insects, birds and rodents (Maier and Cook, 2014).

2 Materials and methods.

The soybean samples used for the study were obtained at a farm in Kuta, Niger State. The soybean samples were depodded manually with hand and dried to a moisture content of 8.3% using sun-drying method at an average temperature of 33°C and relative humidity of 62% for three days.

Hermetic storage bag of 50 kg capacity was obtained from Strategic Grain Reserve Silo Complex, Minna, Niger State and was resized into smaller units of 400 g capacity. Storage jars of one litre capacity were procured from Kure market, Minna, Niger State. The bags and jars were filled with 400 g soybean seeds and sealed properly to prevent the flow of air. A 1 L jar which was pierced on every side was also filled with 400 g of soybean seeds, this served as the control. The filled models were kept in the Departmental laboratory with the temperature and relative humidity of the environment where the models were kept observed and noted four times daily at 6 am, 12 noon, 3 pm and 6 pm.

The grains inside each hermetic model and control were stored for eight weeks and the quality of the stored grain in each model was assessed at an interval of two weeks. The quality parameters assessed were the hectolitre weight, ash content, crude fibre, crude fat, crude protein, carbohydrate, dry matter and moisture content of the grain. Figure 1 shows samples of the depodded soybeans used for the experiment.

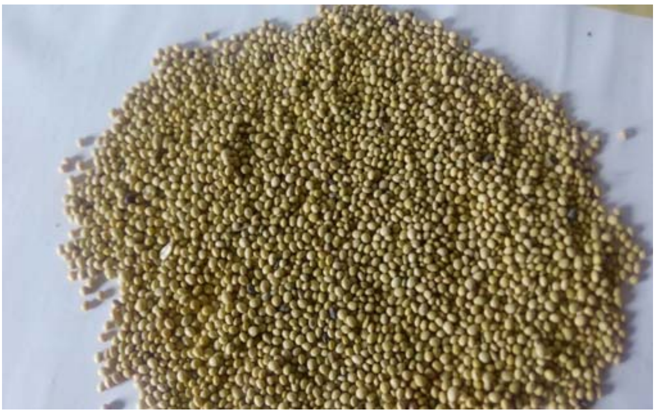

Figure 1 Depodded soybean seeds

2.1 Proximate analysis

The proximate compositions of the stored samples were determined prior to storage and also during the storage period. These were determined using standard methods of Analysis of AOAC (2000). The following parameters were determined: moisture content, ash content, crude fibre, crude fat, crude protein and carbohydrate.

2.2 Other quality parameters determined

Other quality parameters determined include dry matter and hectolitre weight. The dry matter was determined according to the method described by Uchechukwu-Agua et al. (2015). Percentage of dry matter was estimated by using % dry matter = 100 - moisture content. The hectolitre weight was determined according to the method described by Manley and Geyer (2006).

3 Results and discussion

The results of the proximate composition and other quality parameter of stored soybean seeds in the models and the control are as presented in Tables 1 to 4. The comparison of the results was carried out using Analysis of Variance.

Table 1 Proximate composition of soybean seeds stored in the control

Duration, week	Fat, %	Ash, %	Fibre, %	Protein, %	CHO, %	Moisture content, %
0	15.23±0.00c	6.12±0.03b	5.18±0.00d	44.18±0.10c	20.94±0.06b	8.36±0.06a
2	13.74±0.01b	5.43±0.00ab	5.01±0.01c	43.84±0.44b	21.68±0.35a	10.30±0.34b
4	11.95±0.02a	3.19±0.02a	4.32±0.01b	42.54±0.35b	27.17±0.06c	11.27±0.06c
6	11.04±0.01a	2.74±0.02a	3.92±0.00a	37.43±0.51a	32.19±0.11c	12.23±0.12d
8	10.93±0.04b	2.10±0.03a	3.90±0.06a	38.12±0.22c	32.15±0.25b	12.50±0.06e

Note: * Values followed by same superscript alphabet are not significantly different at (P<0.05) along the columns. Values are Mean ± SEM of triplicate determination.

Table 2 Proximate composition of soybean seeds stored in the air-tight bag

Duration, week	Fat, %	Ash, %	Fibre, %	Protein, %	CHO, %	Moisture content, %
0	15.23±0.00d	6.12±0.00d	5.18±0.01a	44.18±0.51d	20.94±0.06a	8.36±0.0d
2	13.55±0.01b	2.41±0.01a	6.73±0.01d	44.16±0.28d	26.70±0.06b	7.80±0.06c
4	12.20±0.02c	3.47±0.00b	4.05±0.00a	41.26±0.13c	31.77±0.08b	5.93±0.09b
6	10.55±0.00a	6.22±0.02d	6.10±0.03c	38.40±0.32b	33.17±0.07d	5.57±0.07a
8	10.31±0.33d	4.75±0.01c	4.47±0.01b	37.78±0.16a	36.23±0.12c	5.46±0.05a

Note: * Values followed by same superscript alphabet are not significantly different at (P<0.05) along the columns. Values are Mean ± SEM of triplicate determination.

Table 3 Proximate composition of soybean seeds stored in the air-tight jar

Duration, week	Fat, %	Ash, %	Fibre, %	Protein, %	CHO, %	Moisture content, %
0	15.23±0.02b	6.12±0.01e	5.18±0.02c	44.18±0.20e	20.94±0.06a	8.36±0.06d
2	13.15±0.00c	4.69±0.00d	9.10±0.00e	43.52±0.47d	22.30±0.57b	7.23±0.06c
4	11.10±0.05a	1.22±0.01a	4.78±0.01a	40.32±0.30c	36.25±0.13d	6.33±0.15b
6	9.82±0.02d	4.60±0.00c	7.78±0.00d	39.03±0.58b	32.63±0.63c	6.13±0.15b
8	9.59±0.04e	3.86±0.03b	4.06±0.05b	38.18±0.32a	34.54±0.34d	5.77±0.12a

Note: *Values followed by same superscript alphabet are not significantly different at (P<0.05) along the columns. Values are Mean ± SEM of triplicate determination.

Table 4 Result of other quality parameters of soybean seed during the storage

Samples	Duration, week	Hectolitre weight, hl kg^{-1}	Dry matter, %
Control	0	72.30±0.20a	91.63±0.06e
	2	85.23±0.59e	89.70±0.35d
	4	75.00±0.17b	88.73±0.06c
	6	82.97±0.12d	87.77±0.16b
	8	76.17±0.16c	87.43±0.06a
Bag	0	72.30±0.20a	91.63±.058a
	2	80.13±1.21b	90.20±0.10b
	4	104.33±2.76d	94.07±0.15c
	6	70.17±0.15a	94.43±0.16d
	8	85.57±0.06c	94.53±0.06d
Jar	0	72.30±0.20a	91.63±0.06a
	2	85.23±0.59d	92.77±0.06b
	4	96.17±1.60e	93.67±0.15c
	6	73.97±0.15b	93.87±0.15c
	8	82.17±0.12c	94.23±0.16d

Note: * Values followed by same superscript alphabet are not significantly different at (P<0.05) along the columns. Values are Mean ± SEM of triplicate determination.

3.1 Effect of the storage models on the moisture content of soybean seeds

The result from Table 1 showed that the moisture content of soybean seed in the control increased from 8.36% to 10.30%, 11.26%, 12.23% and 12.50% for two weeks, four weeks, six weeks and eight weeks, respectively. It was observed that the moisture level of the seeds in the bag decreased from its initial level of 8.36% to 7.80%, 5.93%, 5.57% and 5.46% which was similar to the seeds stored in the jar which also experienced a decrease from 8.36% to 7.23%, 6.33%, 6.13% and 5.77% respectively after eight weeks of storage. According to Ebubekir (2007), the moisture content of grains affects their mechanical and physical properties. It also affects the storability, processing and handling of biomaterials.

Statistical analysis shows that moisture content of the seeds in the control increased significantly (P<0.05) from

8.36% to 12.50% after eight weeks of storage. The increase in the level of moisture in the control could be as a result of the absorption of moisture from the environment during storage. There was a decrease in moisture content in the samples stored in the bag and jar from 8.36% to 5.46% and 8.36% to 5.77%. The decrease in moisture content in bag and jar may be as a result of lack of absorption of moisture from the environment and the prevalent low oxygen level which reduced the survival of insects and weevils in the stored grains (Jayas et al., 1993).

3.2 Effect of the storage models on the fibre content of soybean seeds

The result showed that the fibre content of the samples in the control decreased from 5.18% to 5.01%, 4.32%, 3.92% and 3.90% for two weeks, four weeks, six weeks and eight weeks respectively (Table 1). This result shows a significant decrease (P<0.05) from 5.18% to 3.90%. The crude fibre of the sample in bag increased from 5.18% to 6.73% after two weeks, 4.05% at the end of four weeks, 6.10% at the end of six weeks and 4.47% at the end of the eight weeks (Table 2). That of jar also increased from 5.18% to 9.10%, 4.78%, 7.78% and 4.06% respectively (Table 3). Dietary fibre is the edible part of plant or analogous carbohydrates that are resistant to digestion and absorption in the small intestine.

Statistical analysis shows that crude fibre significantly decreased (P<0.05) in the control, bag and jar from 5.18% to 3.90%, 5.18% to 4.47% and 5.18% to 4.06% respectively. This result is similar to the result achieved by Fagbohun and Lawal (2014) who reported a depletion from 0.48% in fresh cassava sample to 0.23% in sundried sample stored for twenty weeks.

3.3 Effect of storage models on protein content of soybean seeds

Tables 1-3 showed that there was a progressive decrease in the protein content of the soybean seeds stored in the control and the two models. It was observed that the protein content of soybean seeds stored in the control decreased from 44.18% to 43.84%, 42.54%, 37.43% and 38.12%, that of the bag was from 44.18% to 44.16%, 41.26%, 38.40% and 37.78% for two weeks, four weeks, six weeks and eight weeks respectively. While the soybean seed stored in the jar also decreased from 44.18% to 43.52%, 40.32%, 39.03% and 38.18%. Proteins are vital component of diet required for the survival of human and animals and the basic function of protein in nutrition is to provide adequate amount of amino acids (Pugalenthi et al., 2004).

The statistical analysis showed that the storage model had significant effect on the protein content of the soybean seeds. The protein content of the soybean seeds decreased significantly (P<0.05) in the three samples: from 44.18% to 38.12% in the control, 44.18% to 37.78% in bag, and 44.18% to 38.18% for the jar.

3.4 Effect of storage models on the fat content of soybean seeds

Tables 1-3 showed a decrease in fat content in the control and the two storage models. The fat content of soybean seeds in the control decreased from 15.23% to 13.74%, 11.95%, 11.04% to 10.93% while that of bag decreased from 15.23% to 13.55%, 12.20%, 10.55% to 10. 31%. In addition, the fat content of jar also decreased from 15.23% to 13.15%, 11.10%, 9.82% to 9.59% for two weeks, four weeks, six weeks and eight respectively.

Statistically, the storage model had significant effect on the fat content of the stored soybean seeds. There was a significant decrease (P<0.005) in the fat content of the control and the two models. The control decreased from 15.23% to 10.93%, 15.23% to 10.31% for bag while that of jar was 15.23% to 9.59%, which agrees with the findings of Lawal and Fagbohun (2012) who reported a decrease in fat content of millet seeds from 4.55% in freshly harvested samples to 3.55% in sun-dried samples stored for 6 months. The reduction could be as a result of the decrease in protein content.

3.5 Effect of storage models on the carbohydrate content of soybean seeds

The result showed a general increase in the carbohydrate content of soybean seeds across the control and the two storage models (Tables 1-3). The soybean seeds in the control increased from 20.94%, to 21.68%, 27.17%, 32.19% and 32.15% (Table 1). While that of the bags increased from 20.94% to 26.70%, 31.77%, 33.17% and 36.23% for two weeks, four weeks and six weeks respectively (Table 2). The jar sample increased from

20.94% to 22.30% at the end of two weeks, 36.25% at the end of four weeks, 32.63% at the end of six weeks and 34.54% at the end of eight weeks (Table 3).

Statistical analysis shows that the storage models had significant effect on the carbohydrate content of soybean seeds. The carbohydrate content increased significantly (P<0.05) in the two storage models which agreed with the investigation of Fagbohun et al. (2011) who affirmed an increase in the percentage of carbohydrate of freshly shelled melon seeds (*Citrullus vulgaris*) from 0.56% to 1.56% in sundried sample after twenty weeks of storage.

3.6 Effect of storage models on the ash content of soybean seeds

Table 1 showed that the ash content of the soybean seeds stored in the control decreased from 6.12% to 5.43%, 3.19%, 2.74% and 2.10% for two weeks, four weeks, six weeks and eight weeks respectively. It was observed that there was also a decrease in ash content for the samples stored in the bag from 6.12% to 2.41% at the end of two weeks, 3.47% at the end of four weeks, 6.22% at the end of six weeks and 4.75% at the end of eight weeks (Table 2). The ash content of the samples in the jar decreased from 6.12% to 4.69%, 1.22%, 4.60%, and 3.86% (Table 3).

Statistical analysis shows that ash content in the control decreased progressively. The ash content decreased significantly (P<0.05) in the control, bag and jar from 6.12% to 2.10%, 6.12% to 4.75% and 6.12% to 3.86% respectively.

3.7 Effect of storage models on the dry matter content of soybean seeds

The results in Table 4 indicated that there was a significant decrease (P<0.05) in the dry matter of the control sample. The dry matter content decreased from 91.63% to 89.70%, 88.73%, 87.77% and 87.43% for two weeks, four weeks, six weeks and eight weeks respectively. This is as a result of the increase in the moisture content as seen in Table 1. It was observed that the dry matter content of the bag and jar sample increased significantly. That of the bag sample increased from 91.63% to 90.20%, 94.07%, 94.43% and 94.53%; while that of the jar increased from 91.63% to 92.77%, 93.67%, 93.87% and 94.23%. The increase in the bag and jar sample is as a result of decrease in the moisture content.

3.8 Effect of storage models on hectolitre weight of soybean seeds

The results in Table 4 indicated that there was a significant increase (P<0.05) in the hectolitre weight of all the stored samples; these varied from the initial weight of 72.30-76.17 hl kg^{-1} for the control; 72.30-85.57 hl kg^{-1} for bag and 72.30 to 82.17 hl kg^{-1} for jar. The increment observed could be as a result of change in temperature and relative humidity during storage.

4 Conclusion

From the results obtained from the comparative analysis of the effect of hermetic storage models on the quality parameters of soybean seeds carried out in this study, the following conclusion can be deduced: the moisture content increased significantly in the control but reduced significantly in the bag and jar throughout the period of storage. Crude fibre, fat, ash and protein decreased significantly in all the models including the control throughout the period of storage. However, carbohydrate and hectolitre weight increased significantly in all the models including the control throughout the period of storage. Furthermore, dry matter decreased in the control samples while it increased in the jar and bag throughout the period of storage of eight weeks. Thus, it can be concluded that the hermetic storage models had effect on some of the quality parameters of the stored soya samples.

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