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SAFE STORAGE AND PREVENT SPOILAGE OF FLAX SEEDS

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Abstract

The experiments were conducted directly after the flax harvest season with the object of conditioning the flaxseeds in optimal condition to preserve them in storage as long as possible using different types of storage bags. The measurements during the storage period such as moisture content of seed inside the bags, temperature, the percentage of carbon dioxide , oxygen, peroxide value and free fatty acids, as well as fatty acid ratios. The results showed that, during the storage process, the carbon dioxide concentration with bags (type 7 layers) showed the highest levels of CO_2 concentration which increased from 0.1 to 21.3 %, from 0.1 to 20.5 % and from 0.0 to 19.8 for the non-treated seeds, conduction heat treated and infrared heat treated. seeds respectively after six months of storage and starts to decrease again during the winter months due to lower seeds temperature and respiration rate. While the bags (type 3 layers) showed an increase of CO_2 level from 0.1 to 16.8 %, 0.1 to 16.4 % and from 0.0 to 16 for the non-treated, conduction heat treated and infrared heat treated seeds respectively. However burlap bags showed CO_2 levels ranged from 0.1 to 0.2 % for both treated and non-treated flaxseeds. Also, The total microbial load at the end of storage period approached 885, 861 and 3,512 colonies/g for the non-treated flaxseeds stored in plastic bags 3 and 7 layers and burlap bags respectively. While, the corresponded values for the conduction heat treated flaxseeds were 196, 180 and 2,310 colonies/g respectively. And for the Infrared heat treated seeds were 178, 163 and 1,240 colonies/g respectively. However, at the end of the storage process both bags types 3 and 7 layers recorded lower peroxide value and free fatty acid in comparison with burlap bags during the storage time which indicated good oil quality of the stored seeds. In general, Storage of flaxseeds in both types of tested hermetic bags showed safe storage of flaxseeds with keeping the final quality in comparison with burlap bags.

Key words: *flax, burlap , hermetic bags, free fatty acid, storage, peroxide value, and carbon dioxide*

INTRODUCTION

Flaxseed is considered one of more important of seeds in foodstuffs, as it contains energy, carbohydrates, dietary fibres, proteins, monounsaturated fats, saturated diets, and many vitamins such as riboflavin, thiamine, vitamin B5, vitamin B6, folic acid, and vitamin C, and many mineral salts, such as calcium, iron, magnesium, phosphorus, potassium, zinc, and omega-3 acid.
This part will be covered the heat treatment and storage, Atmosphere storage, hermetic Storage
Thermal treatments are important before storing seeds.
Morais *et al* (2011) [11] examined if the use of heat treatment and storage of the whole brown flaxseed flour would negatively affect the functional and sensory properties or not, such as a decrease in the linolenic acid content, an increase in the lipid peroxide value, and other organoleptic changes such as color and flavor changes. The seeds were treated in an oven at 150°C for 15 minutes. It was milled to obtain a 20 mesh particle size flour and then samples were then stored with or without synthetic antioxidants (BHA and BHT together, at a rate of 100 ppm each), for thirty days. The linolenic acid content and lipid peroxide value were determined and the color and flavor were assessed.
Malcolmson *et al.* (2014) [9] examined storability of two samples from two different types of flaxseeds, one of the linottt cultivar and the other mixed of several varieties. They were stored in paper bags with plastic liners for 128 days at a temperature of 23±2°C, and

it was found that the peroxide value in both samples was not significantly affected during the entire storage period. Measurements are at 0, 33, 66, 96 and 128 days. Only the linott sample showed an excess of free fatty acids and this could be due to the presence of immature seeds in the sample.

Herchi *et al.*(2016) [7] studied the effects of heating processes on antioxidant activity of flaxseed hull oil and some quality characteristics. There was a significant decrease in oil stability during heating process. Heating process caused loss of and chlorophyll pigments, total flavanoids, carotenoids and total phenolic acids,. Phospholipids content were less changed compared to other bioactive compounds. Antioxidant activity of flaxseed hull oil decreased during heating process.

Singh *et al.* (2017) [14] A result refer to, seed health during storage has been found to be influenced by the seed quality. Seed storage and retention of seed viability is important consideration in agricultural practice. Poor storage conditions greatly affect seed vigor. The deterioration rate depends on storage condition that is temperature, relative humidity, moisture contents of seed, types of storage container. Types of container also regulate temperature, relative humidity, and seed moisture contents. High temperature, relative humidity, and moisture in the storage environment appear to be principle factors involved in deterioration of seed quality.

Fouda et. Al (2021) [6] using radiation density 331.6 W/m^2 and the exposure time of 15 min for infrared heating are recommended to decrease the moisture content of flaxseeds to the safe level and the percentage of free fatty acids at the range of 0.3 and 0.56±0.02 respectively, and peroxide value at the range of 2.82 and 1±0.02 respectively and heating methods to test the heat conditioning and oil stabilization of flaxseeds and he recognized the heating surface temperature of 105^{o}C and the exposure time of 12 min for conduction heating and

Modified Atmosphere storage:

Meena *et al.* (2017) [10] reported that farmers, traders normally pack the seeds of various crops in either polythene bags, gunny bags or cloth bags before being used for propagation in the next season. Due the seeds sensitivity to oxidation and variation in moisture content during the storage, period many seeds loose viability during the storage. While maintaining the quality, It has been found that storing the fruits, vegetables and dry fruits under vacuum packed bags enhance the shelf life. The seed is utmost necessary to maintain the viability and Vigour, because it is an essential input in agriculture. Many a times, it so happens that the good quality seed is not available to the farmers in time due to various reasons, the average productivity of most of the crop plants has gone down Considerably in the last one decade and one of the reasons for such decline is the poor quality of seeds being used by the farmers. Vacuum packaging has been found to be superior technology in preserving the seed quality of different field crops.

Capilheira *et al. (*2019) [5] stored under different periods, and the containers used were (permeable, hermetic package inside the permeable package and hermetic package inside the permeable package with CO_2 injection) Storage periods (0, 45, 90, 135, 180, 225) in sealed packages and evaluated different packages for storing soybean seeds with or without adding CO_2 (modified atmosphere) The results were the hermetic package, with and without CO_2 injection, decreases the speed of deterioration of soybean seeds. The hermetic package allows a higher physiological quality of soybeans compared to the permeable package, with a storage period of up to 180 days under uncontrolled environmental conditions. The addition of CO_2 inside the hermetic packages favors the maintenance of the physiological quality of soybean seeds in storage. Multi-layer paper was also used with or without injection of CO_2 and the storage inside was evaluated for a period of 225 days and evaluated every 45 days and from the tests that were done during Storage periods are moisture content, germination rate, emergence of seedlings, accelerated aging and electrical conductivity.

Shinde and Hunje (2019) [13] modified atmospheric gases to test seed health and seed viability of kabuli chickpea varieties. The results of study revealed that at the end of 14 months of storage the modified atmospheric gaseous combinations of CO_2 (80%) + N_2 (20%) + O_2 (0%) (C_2) recorded significantly highest seed germination 92.38 % with zero percent of seed infestation and seed infection compared to control C^1 88.75 , 9.38 and 29.49 %, respectively. This technology can be used an alternative to chemicals which is safe, ecofriendly for maintaining quality of organically produced seed and its longevity.

Hermetic Storage of oil seed crops:

Amadou *et al.* (2016) [4] evaluated the performance of hermetic triple layer Purdue improved Crop Storage (PICS) bags for protecting Hibiscus sabdariffa grain against storage insects. When we stored infested H. sabdariffa grain for six months in the woven polypropylene bags typically used by farmers, the Spermophagus population increased 33-fold over that initially present. The mean number of emergence holes per 100 seeds increased from 3.3 holes to 35.4 holes during this time period, while grain held for the same length of time in PICS bags experienced no increase in the numbers of holes. weight loss of grain in the woven control bags was 8.6% while no weight loss was observed in the PICS bags.

Afzal *et al.* (2017) [1] Seed moisture content increased in polypropylene bags while it remained constant in PICS bags. No change in germination was observed in maize seeds stored in PICS bags while in polypropylene bags it was reduced in half when compared to the initial germination. Seed stored in these containers is susceptible to fluctuating seasonal relative humidity and temperature, which promote mold and insect growth. So the performance of Purdue Improved Crop Storage (PICS) bags for maize seed storage during a two-month period is studied. Seed stored in polypropylene bags had higher insect damage with a weight loss of 35% while in PICS bags the infestation was minimal with a weight loss of about 3%. Higher aflatoxin contamination levels were observed in seeds stored in polypropylene than PICS bags.

Walsh *et al*. (2014) [15] noticed reduced physical losses, ability to sell seed (and grain) over a longer period and achieve a better price, improved quality of seed leading to lower seeding rates, improved plant vigor, and – ultimately – improved yields. When used the hermetic storage also provide economic advantages to farmers.

Okolo *et al.* (2017) [12] confirmed the various types and diversity of hermetic storage structures, best practices in terms of use, capacity of best fit, and their consequent unique advantages/shortcomings in terms of cereal grains storage in the tropics were reviewed to aid farmers to make the right choices and achieve better results. And reviewed efficacy, diversity and potentials of hermetic storage (HS) technology and its ability to solve numerous storage related challenges abound, and prevalent in the tropics.

Afzal *et al.* (2019) [2] Stored seeds of moringa were at 8, 10 and 12% seed moisture contents (SMC) in hermetic (super) and traditional (cloth) bags for six months. Highest germination (70%) and vigor were found in hermetically sealed super bag at 8% SMC after storage and estimated the optimum conditions for moringa seed to maintain its quality during storage. Under humid environment, seed storage in cloth bag should not be practiced as it increases equilibrium seed moisture contents, which promotes seed deterioration. Seed stored in hermetically sealed super bags retained higher oil and protein contents as compared to cloth bags.. In conclusion, it is recommended that moringa seeds must be stored in hermetically sealed super bag at 8% SMC for preservation of seed quality.

Kamran *et al.* (2020) [8] stated that, the both genotypes exhibited better seed quality attributes at the first picking, and zeolite beads dried seed to lowest moisture content more quickly than sun-drying. The efficiency of storage systems was evaluated by estimating moisture content and germination potential periodically in the storehouse and later under field conditions. Seeds of both genotypes stored hermetically retained the lowest moisture content, maximum germination potential, and lower fatty acid contents throughout the storage period, as well as performing significantly better in the field by exhibiting early and uniform stand establishment, more fruiting branches and bolls, and higher yield.

Alemu *et al.* (2021) [3] decisions to use different storage methods are poorly understood. so the economics of hermetic grain storage technology among 450 representative small-scale maize farmers, the hermetic bags, being promoted in Ethiopia, could be viable alternatives to traditional methods and insecticides that are commonly used by farmers to store grain. The economics and determinants behind farmers' North Western Ethiopia. Gross margin (GM), and the marginal rate of return (MRR) were employed to estimate the economic costs and benefits of storage methods, while a multivariate probit regression model was employed to analyze the determinants of farmers' decision to store maize with a given storage method. The results show that farmers used a combination of different storage techniques: 19.6% did not store grain, 87.8% used traditional methods with pesticide, and 66.7% used Purdue Improved Crop Storage (PICS) hermetic bags. Farmers who used hermetic bags also used other mentioned storage techniques.

The Egyptian farmer prefer flax cultivation but facing the difficulty in storage and the fast deterioration and damage of seeds also resort to extract oil and fiber from flax. A lot of problems such as increased moisture content of seeds as well as its oil content and other elements made the Lipase enzyme activates and caused oil rancidity and thus reducing seeds quality. The increase in oil rancidity may be caused by a break or crack the seeds that cause the oil release from the seeds during harvesting or as a result of inconvenient storage of the seeds. Methods of seeds pre-treatment prior to storage were varied to thermal, chemical and biological methods. These methods cause a good conditioning of seeds to be proper for safe storage process. It can also control of seeds moisture content, microbial activity, respiration rate and inhibition of enzymes causing rancidity specially for oil seed crops. In Egypt most of traditional storage methods are burlap bags causing seeds moisture absorption, insect infestation and fungal growth. All these factors increased the percentage of deteriorated seeds.

Flax storage considerations were important for deteriorating conditions this work was attempted can contribute to safe storage and prevent spoilage of flax seeds.

MATERIALS AND METHODS

Experiments evaluate two different methods of heating treatment to predict the longest and safe storage period of flaxseeds without biological infestation and minimize the storage losses in hermetic bags. Also Monitoring changes on moisture reduction, heat stabilization, microbial load reduction during storage period 245 day. The sources of heat conduction and Infrared heating was developed to be suitable for seeds prior to storage process. The heat-treated seeds were stored in two different types of storage bags (3&7 layers hermetic bags) and compared with the non-treated seeds. Quality evaluation tests were also conducted for the heat-treated seeds after the heat-treating process and along the storage period.

Sampling Flaxseeds colors is brown. Most types of these basic varieties have similar nutritional characteristics and equal numbers of short-chain Omega-3.

Hermetic bags

Two different types of barriers films were developed for the experimental work. The materials specifications of the barrier films were assessed in the laboratory of Shuman company to assess the most proper film for cowpea storage; the developed films were formed into a shape of bags with capacity of 20 kg/bag.

Methods

Treatments of storage process

The optimum heating condition under conduction and infrared heat treatment was selected for seeds treatment prior to storage process. The heat treated and non-treated seeds were stored in different types of hermetic bags (7 layers – 3 layers) and compared with the seeds stored in the traditional purlab bags. In this experiments we adjust the heating surface temperature of 105C° and the exposure time of 12 min for conduction heating and radiation density 331.6 W/m^2 and the exposure time of 15 min for infrared heating were recommended.

Figure 1 illustrates a schematic diagram for the storage experimental treatments.

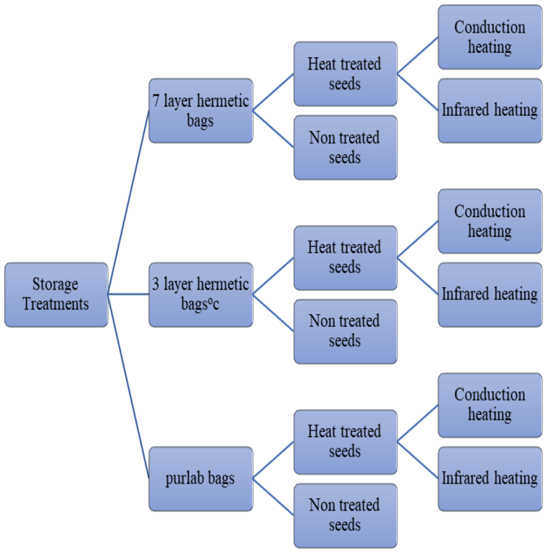

Fig. 1. Experimental treatment for the storage process
Source: Authors' drawing.

Measurements

The final quality (F.F.A – Peroxide value – F.Acids) as determined by the Food Technology Research Institute, Department of Oil Research, Agricultural Research Center were selected for the storage experiments.

Testing condition for different types of multi-layer poly-ethylene bags

The materials specification of the barrier films were assessed in the laboratory of the company. Two different types of barriers films were developed in cooperation with a local company (Shuman Co.). To assess the most proper films for flaxseeds storage, the developed films were formed into a shape of bags with capacity of 50 kg/bag.

The produced bags were filled by the non-treated flaxseeds at initial moisture content 11.11 % d.b. and stored inside storage chamber installed at rice Mechanization center (Kafr El- Sheikh gov.) during the flax harvesting season. The storage process at this stage was done for the treated and non-treated seeds. The evaluation basis of the developed bags included CO_2 percent (%), O_2 percent (%) using the equipment and relative humidity for air in the bags using the equipment seeds moisture content, microbial level and oil quality of the stored seeds in terms of % FFA, Peroxide value and Acidity of the extracted oil.

Experimental procedure for the laboratory scale storage of flaxseeds

1-The required amount of seeds were collected for storage and prepare the store for the storage process.

2-The bags were Catted and welded to bear 10 kg and fill them by the treatments of heat treated flaxseeds and non-treated samples.

3-The filled bags were installed over wooden bars in three stocks (Two stocks represent different types of plastic films and the third stock represents the traditional storage in burlap bags).

4-The percentage of oxygen, carbon dioxide and relative humidity in all bags were measured and taken a sample from each experimental stock to analyze the quality factors changes at one month intervals.

RESULTS AND DISCUSSIONS

Storage of Flaxseeds using different types of hermetic bags

Flaxseeds treated and non-treated were stored in 3 types of bags (3, 7 layers polyethylene hermetic bags and burlap bags) for nine months. The obtained results could be presented as follows:

Seeds Bulk temperature

As shown in Figures 2, 3 and 4. The temperature oscillation decreased with seeds depth inside the tested stocks for both conditions of flaxseeds (treated and non-treated seeds). The recorded seeds bulk temperature for the non-treated seeds ranged from 18 to 30.6, 19 to 31 and 20.6 to 32.8°C for the 7 and 3 layers hermetic bags and the burlap bags respectively. While, the corresponding values for the conduction heat treated seeds ranged from 17.2 to 30, 18.3 to 30.2 and 19.9 to 32°C for the 7 and 3 layers hermetic bags and the burlap bags respectively.

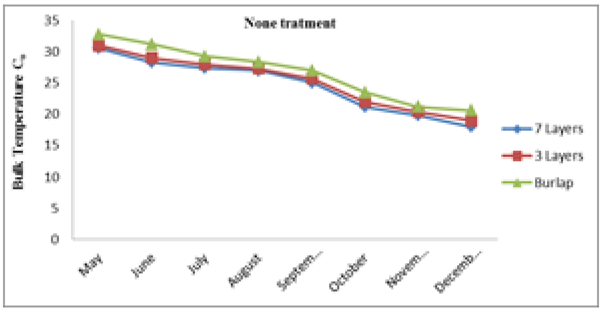

Fig. 2. Effect of the non-treated seeds and bags type on seeds bulk temperature during the storage time.
Source: Authors' determination.

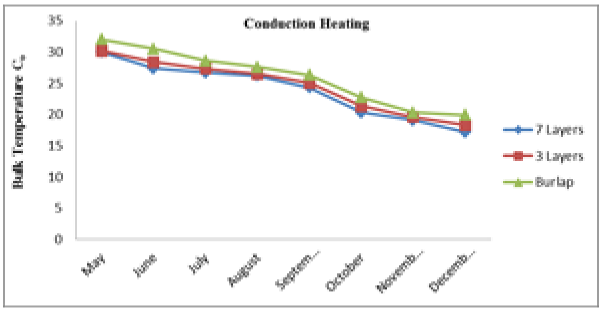

Fig. 3. Effect of conduction heated seeds and bags type on seeds bulk temperature during the storage time
Source: Authors' determination.

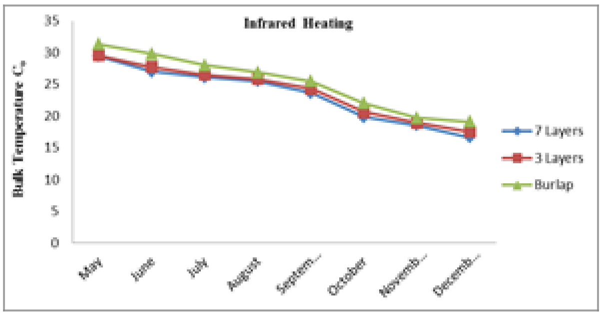

Fig. 4. Effect of the infrared heated seeds and bags type on seeds bulk temperature during the storage time.
Source: Authors' determination.

The bulk temperature of the infrared heat treated seeds ranged from 16.6 to 29.4, 17.5 to 29.5 and 19.1 to 31.3°C for the 7 and 3 layers hermetic bags and the burlap bags respectively.

Seeds Moisture content in different types of bags

The change in seeds moisture content depends on initial moisture content and absorption of moisture content from outside. As shown in Figures 5, 6 and 7 the seeds moisture content decreased in all types of bags.

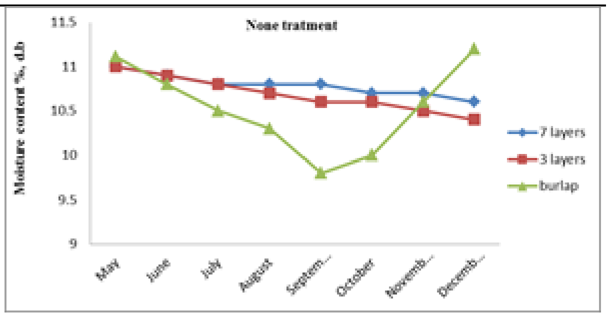

Fig. 5. Effect of the non-treated seeds and bags type on seeds moisture content during the storage time.
Source: Authors' determination.

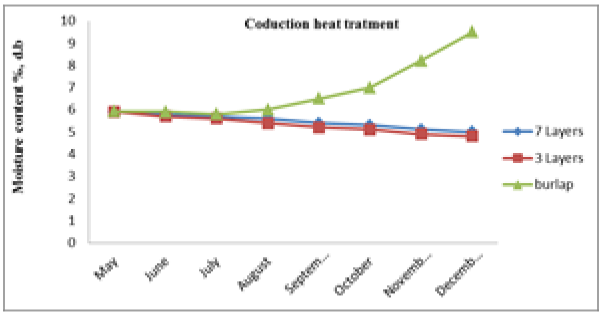

Fig. 6. Effect of conduction heat treated seeds and bags type on seeds moisture content during the storage time.
Source: Authors' determination.

The recorded moisture content for the non-treated seeds ranged from 11 to 10.6, 11 to 10.4 and 11.11 to 11.2 % for the 7 and 3 layers hermetic bags and the burlap bags respectively. While, the values for the conduction heat treated seeds ranged from 5.91 to 5, 5.9 to 4.8 and 5.92 to 9.5 % for the 7 and 3 layers hermetic bags and the burlap bags respectively. The moisture content of the infrared heat treated seeds ranged from 9 to 7.8, 9 to 7.4 and 9.1 to 11.4 % for the 7 and 3 layers hermetic bags and the burlap bags respectively.

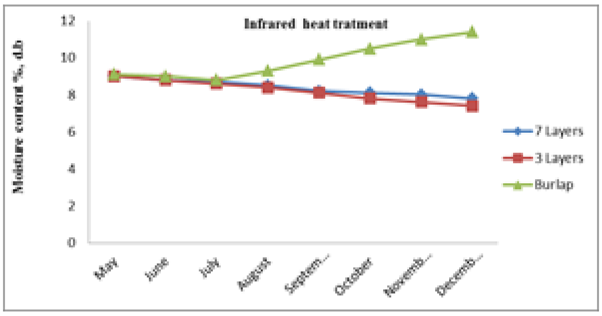

Fig. 7. Effect of infrared heat treated seeds and bags type on seeds moisture content during the storage time
Source: Authors' determination.

CO_2 concentration inside different types of bags

As shown in Figures 8, 9 and 10 . The results show that, The Plastic bags type 7 layers showed the highest levels of CO_2 concentration which increased from 0.1 at the early stage of storage to 21.3 %, from 0.1 to 20.5 % and from 0.0 to 19.8 for the non-treated samples, conduction heat treated and infrared treated samples respectively.

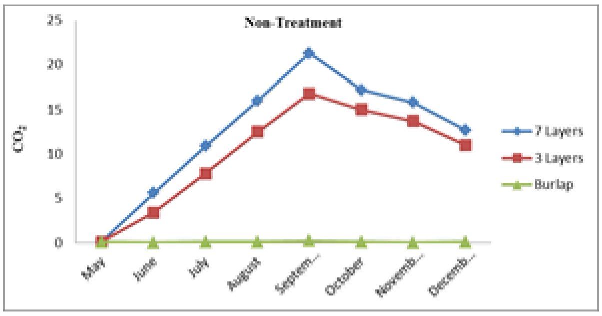

Fig. 8. Effect of the non-treated seeds and bags type on CO_2 concentration during the storage time
Source: Authors' determination.

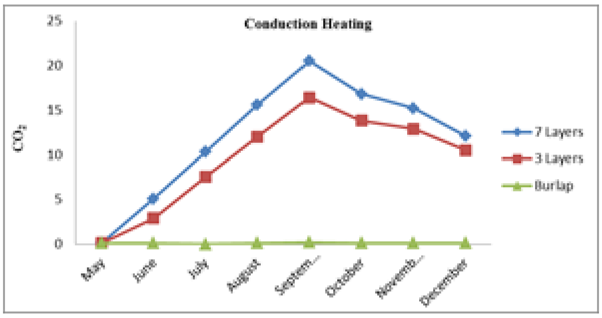

Fig. 9. Effect of conduction heated seeds and bags type on CO_2 concentration during the storage time
Source: Authors' determination.

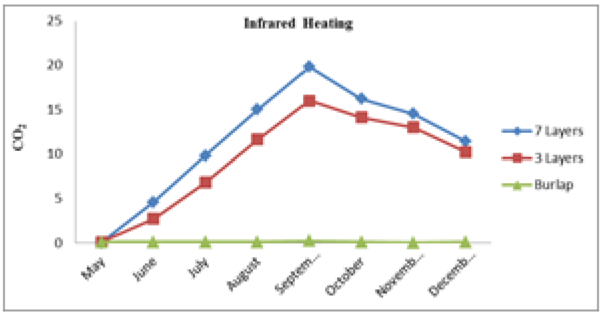

Fig. 10. Effect of infrared treated seeds and bags type on CO_2 concentration during the storage time
Source: Authors' determination.

The above mentioned levels starts to decrease again during the winter months due to lower seeds temperature and respiration rate. The storage bags type 3 layers showed an increase of CO_2 level from 0.1 to 16.8 %, 0.1 to 16.4 % and from 0.0 to 16 for the non-treated, conduction heat treated and infrared treated seeds respectively. However the burlap bags showed CO_2 levels ranged from 0.1 to 0.2 % for both treated and non-treated flaxseeds.

Fungal count during the storage period

The contamination levels recorded at the closing of bags suggest that contamination with molds and other microbes are dependent on the seeds conditions. Under the storage conditions in different types of plastic bags, the mold activity is basically stopped, and also the else mycrotoxine production as the level of CO_2 increased. As shown in Figures 11, 12 and 13 the total microbial load at the end of storage period approached 885, 861 and 3,512 colonies/g for the non-treated flaxseeds stored in plastic bags type 3 and 7 layers and burlap bags respectively. While, the corresponded values for the conduction heat treated flaxseeds were 196, 180 and 2,310 colonies/g respectively. But, the microbial values for the Infrared heat treated flaxseeds were 178, 163 and 1,240 colonies/g respectively This means that, both bags types 3 and 7 layers recorded very close values of total microbial count during the storage time.

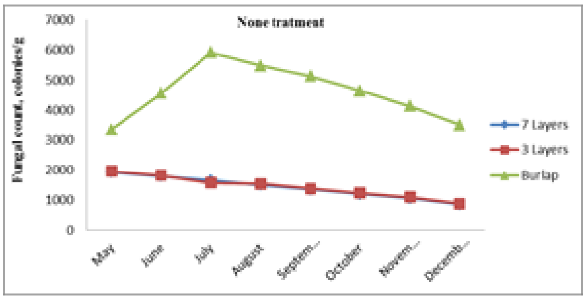

Fig. 11. Effect of the non-treated and bags type on fungal mortality stored seeds during the storage time
Source: Authors' determination.

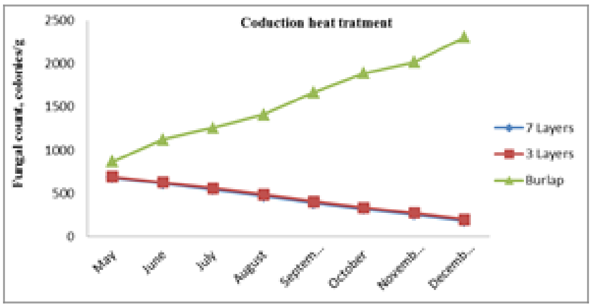

Fig. 12. Effect of the conduction heat and bags type on fungal mortality level during the storage time
Source: Authors' determination.

This may reflect the results of increasing the level of CO_2 and prevention of moisture absorption of hermetic bags which keep the grain in seeds condition and minimize the favorite condition for fungi and other microbial growth.

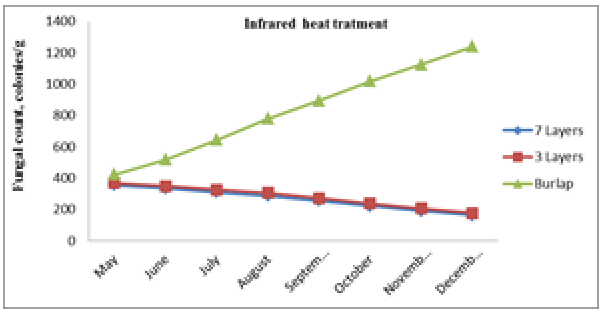

Fig. 13. Effect of the infrared heat and bags type on fungal mortality level during the storage time
Source: Authors' determination.

Seeds oil quality during the storage period

The free fatty Acid (FFA)

The recorded acid value is shown in Figures 14, 15 and 16 at the end of storage period. It was approached 3.34, 3.11 and 7.54 % oleic acid/ Kg for the non-treated flaxseeds stored in plastic hermetic bags type 3 and 7 layers and burlap bags respectively. While, the values for the conduction heat treated flaxseeds were 2.87, 2.74 and 7 % oleic acid/ Kg respectively. But, the values for the Infrared heat treated flaxseeds were 2.75, 2.65 and 6.83 % oleic acid/ Kg respectively.

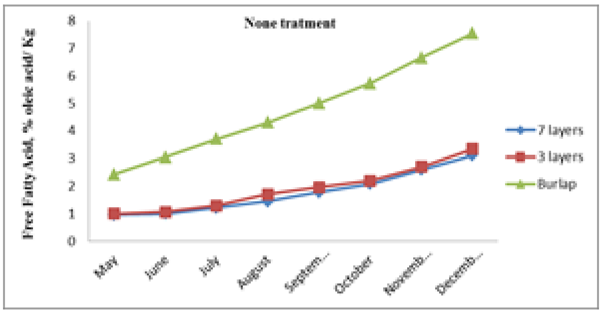

Fig. 14. Effect of the non-heat treated and bags type on free fatty acid values during the storage time
Source: Authors' determination.

This means that, both bags types 3 and 7 layers recorded lower values of free fatty acid during the storage time in comparison with the burlap bags. In general, FFA less than 5 % indicating non-rancidity of the extracted oil.

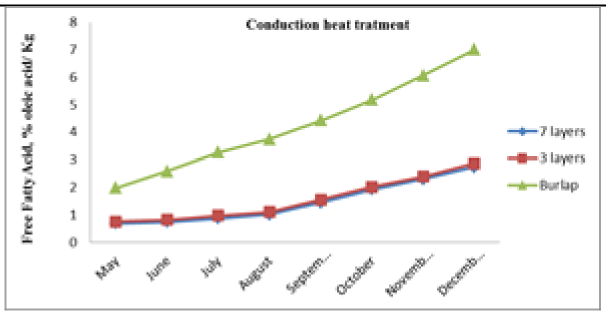

Fig. 15. Effect of the conduction heat and bags type on free fatty acid values during the storage time
Source: Authors' determination.

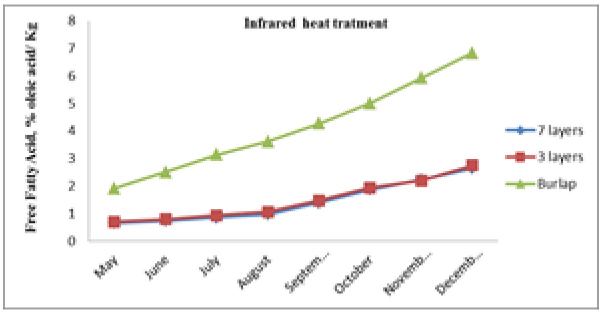

Fig. 16. Effect of the infrared heat and bags type on free fatty acid values during the storage time
Source: Authors' determination.

The peroxide value

The peroxide value recorded as shown in Figures 17, 18 and 19 the peroxide value at the end of storage period approached 22, 21.6 and 28 meqO_2/ Kg Oil for the non-treated flaxseeds stored in plastic bags type 3 and 7 layers and burlap bags respectively. While, the peroxide values for the conduction heat treated stored flaxseeds were 11.4, 11.2 and 17.5 meqO_2/ Kg respectively. And, the values for the Infrared heat treated stored flaxseeds were 10.3, 10 and 17 meqO_2/ Kg Oil respectively.

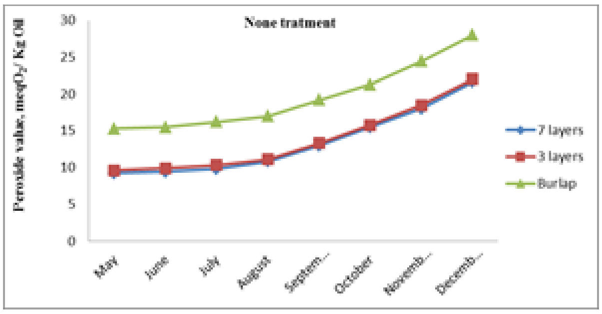

Fig. 17. The change in peroxide values as related to the storage time for the non-treated stored seeds
Source: Authors' determination.

This means that, both bags types 3 and 7 layers recorded lower peroxide values in comparison with burlap bags during the storage time which indicated good oil quality of the stored seeds.

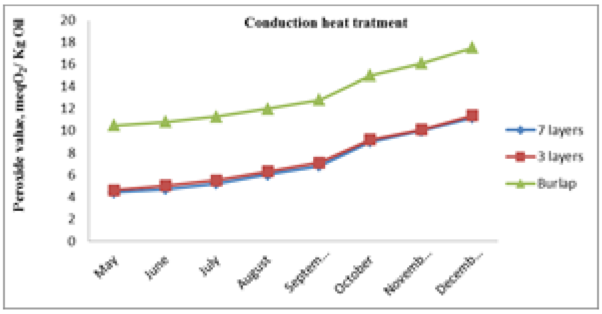

Fig. 18. The change in peroxide values as related to the storage time for the conduction heat treated stored seeds
Source: Authors' determination.

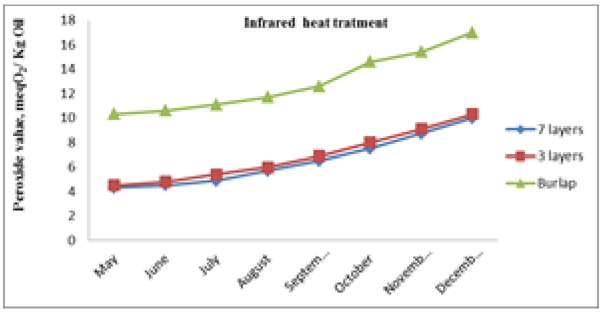

Fig. 19. The change in peroxide values as related to the storage time for the infrared heat treated stored seeds
Source: Authors' determination.

CONCLUSIONS

Two thermal heating units including a rotary dryer and an infrared drying unit were using to storage flax seeds for as long as possible. The heat treated seeds were stored in different types of hermetic plastic bags for 8 months.

Hermetic plastic bag give a good control atmosphere when used for seed storage without deterioration. The principle of this type of bags depending upon full sealing of seeds without moisture absorption and increasing the level of CO_2 inside the bags due to seeds respiration. This condition decreases the level of fungal, microbial and insect growth.

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