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Infra-Red Pre-Treatment of Faba Bean Seeds for Minimization of Anti-Nutritional Factors and Safe Storage in Different Types of Hermetic Bags

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ABSTRACT

The purpose of the current study was to test and assess the impact of treating faba bean seeds with infrared radiation before storing in various kinds of hermetic bags on the quality of seeds during storage. The infra-red pre-heat treatment was conducted under five different levels of radiation intensity, (0.973, 1.033, 1.093, 1.127 and 1.161 kW/m^2), and five different levels of exposure time (120, 180, 240, 300 and 360 sec). The storage experiments were conducted under two different types of plastic hermetic bags (Type-1) 150 micron without anti-fungi substance, while (Type-2) 120 micron with anti-fungi. The traditional Burlap bags were examined as a control treatment. The non-heated and pre-heated seeds were stored for a period of 8 months .The evaluation bases of seeds after pre-heat treatment included the change in seeds moisture content, seeds bulk temperature, trypsin inhibitor activity and fungal colony count. However the measurements of storage experiments included seeds moisture content, bulk temperature, Co_2 concentration, trypsin inhibitor activity, protein content, fungal and insect count. According to the study results, an infrared pre-heating faba bean seed for 240 seconds at a radiation intensity of 1.161 kW/m^2 and storing in plastic hermetic bags treated with anti-fungi (Type-2) is advised for safe storage and preservation of quality.

Keywords: Faba bean, Hermetic storage, Heat treatment, trypsin inhibitor activity, Infra-red

INTRODUCTION

Faba beans (Balady beans) are considered the first leguminous crop in the Arab Republic of Egypt in terms of cultivated area. The importance of this crop is due to its high nutritional value, as its protein content reaches 28% and carbohydrates reach 58%, in addition to many other vitamins. Bean seeds and green pods are used in human nutrition. Meanwhile, the seeds are used as animal food and considered one of the best types of fodder.

The area cultivated with faba bean crop in the Egypt for 2017/2018 season amounted to about 81,361 acres. Thus, the total productivity is 114,759.69 tons. Its cultivation is concentrated in the governorates of Kafr El-Sheikh, Beheira, Dakahlia, and Lower Egypt. (MOA , 2017).

Anti-nutritional factors in legume seeds are natural secondary metabolites that protect plants from biological stresses such as pest attacks. Among the metabolites in question are oligosaccharides that cause flatulence, tannins, phytic acid, and trypsin inhibitors (TIs), with the latter being the most troubling (Khattab and Arntfield, 2009)

Gemede and Ratta, (2014) reported that in legume seeds the main pancreatic enzymes trypsin and chymotrypsin are strongly inhibited by TIs, which reduce dietary protein digestion and absorption by forming complexes that are indigestible even in the presence of large amounts of digestive enzymes.

The anti-nutritional of legumes included soaking, boiling, roasting, microwave cooking, autoclaving, microwave cooking, fermentation, and infrared treatment have become the most common because they are capable of gradually diminishing trypsin inhibitor levels in a time-temperature dependent mode (Khattab and Arntfield, 2009)

Fasina *et al*., (2001) found that, trypsin inhibitor was significantly affected by infrared heat when the legumes were heated at surface temperature of 140°C, with trypsin inhibitor of small seeds of legumes reduced by 35- 50% and protein of legumes was not significantly affected (ranging from 19% to 24%), indicating that protein denaturation occurred during infrared heating and was influenced by the amount of heat that absorbed by the seeds depend on its size.

In comparison to traditional processing, Padmashree *et al*., (2016) investigated the impact of infrared processing on trypsin inhibitor, crude protein, and cooking time of mung bean (Phaseolus aereus) seeds. The results indicated that infrared process caused significant reduction of trypsin inhibitor, greater reduction of cooking time while infra-red process has not made significant change in the crude protein.

A sealed storage system with a changed environment defines what hermetic storage is all about. This suggests that respiration effects typically result in very low oxygen (O_2) and high carbon dioxide (CO_2). The surrounding moisture content remains constant due to the envelope's restricted permeability (Navarro *et al*., 2012).

The main goals of hermetic seed storage are to stop insects from developing further and to kill any insects that are already inside the container by generating an environment with high CO_2 and low oxygen. Additionally, it is utilized to shield the commodity from the high exterior relative humidity levels that are common in hot, humid locations, which helps to avoid mold growth and rodent penetration during storage. Maintaining the germination

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percentage and vigor of seeds is the most important factor to take into account (De Bruin, 2005).

Villers, (2006) mentioned that, hermetic storage is still relatively new compared to earlier storage methods, and its popularity in some niche areas where improved storage techniques are desperately needed is growing. It is now used in around 20 nations. Villers, (2006) also said that, with today's low permeability plastic materials, hermetic storage is becoming more and more common. These materials are lightweight, long-lasting, and, in the case of Super Grain bags, transportable when filled. It has already been determined that pesticide-free hermetic storage technology is appropriate for certain markets. This is particularly true in situations where traditional storage—like those found in warm, humid climates—is unable to sufficiently preserve the item being held for the intended amount of time, leading to significant losses in both quantity and quality.

Future hermetic storage applications are probably going to grow even faster as additional types of hermetic storage become available and more people learn about and appreciate the benefits of this "green" technology (Villers *et al*., 2008).

The current study aims to evaluate the effect of heat treatment for the fully matured faba bean seeds using infrared radiation on the safe storage of seeds throughout the storage period, using different types of innovative and economical hermetic storage bags.

MATERIALS AND METHODS

Materials:

Faba bean (Giza,3 Mohasan ,Var) which is widely cultivated in Egypt and known as a balady bean was used for experimental work. The crop was harvested during 2018 season at a private farm in Kafr El-Sheikh governorate. The seeds were cleaned manually to remove foreign matter and broken or immature seeds. The cleaned seeds were filled in temporary poly ethylene bags and kept in a freezer at -5 °C to prevent any changes of the initial condition of the harvested seeds.

Laboratory scale infra-red heating unit:

An experimental scale rotary infra-red heating unit developed by Matouk, (2009) was used for the experimental work. The unit consists of a rotary cylinder of 35 cm long and 65 cm diameter made of 1mm galvanized iron sheet and insulated from the outside with glass wool. A 15 cm diameter steel flange mounted to the rotary cylinder's side cover and welded to a steel bar sitting on a heavy-duty ball bearing makes up one side of the rotary cylinder coupled to a drive mechanism. A 0.5 kW low speed motor with different sizes of bullies was used for power supply and speed control of the rotary cylinder. The other side of the rotary cylinder serves as an inlet for bean seeds samples through a 10 cm diameter center hole. The heat treated bean seeds discharged through a performed removable sector of the cylinder bottom as shown in Fig.(1). To heat and control the temperature of the infrared heating unit, two ceramic infrared heaters (1kW/each) were installed over two iron blades and placed into the middle iron bar of the spinning cylinder facing the majority of the beans. The heaters may be raised and lowered to change the distance between the ceramic heaters and the bean's surface thanks to two screw rods that were soldered to the iron blades. By adjusting the radiation intensity from the two heaters using an electric circuit with an AC current regulating dimmer, the temperature of the bean layers could be raised and regulated.

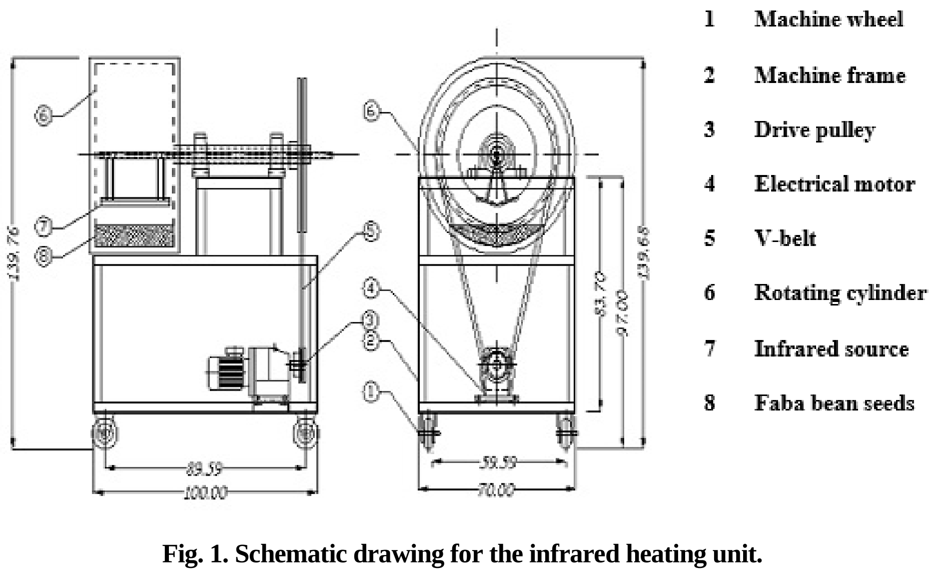

Fig. 1. Schematic drawing for the infrared heating unit.

Testing Conditions:

The laboratory scale infra-red heating unit was tested under five different infra-red radiation intensity levels of (0.973, 1.033, 1.039, 1.127 and 1.161 kW/m^2), five different levels of exposure time (120, 180, 240, 300 and 360 sec) and operated at seeds moisture content of (11.67% wet basis) and constant feed rate of (2 kg/batch).

Two distinct kinds of barrier films were utilized to produce storage bags for the storage procedure. The first type with thickness of 150 micron without anti-fungi substance (7 layers – type 1), while the second is 120 micron with anti-fungi substance (3 layers – type 2) the studied types of hermetic bags were compared with the traditional storage burlap bags.

Table (1) provided the particular material parameters of the barrier films that were employed to make the hermetic bags.

Table 1. Characteristics of the barrier film that was produced.

Property	Unit	Method	Value (Mean ± SD)	
			3 layers with anti-fungi, 120 µm	7 layers, 150 µm
Average thickness	µm	DIN 53,370	120.7 ± 1.27	151 ± 2.00
2 SEGMA thickness tolerance	%		4.7 ± 0.9	2.1 ± 0.10
Width	mm	Internal	442 ± 0.00	442 ± 0.00
Coefficient of friction				
Out/out			0.38 ± 0.03	0.32 ± 0.03
IN/IN	–		0.19 ± 0.01	0.44 ± 0.03
NTR/M		–	–	–
Surface tension	Dyn/CM	DNI ISO 8296	38 ± 0.00	38 ± 0.00
Tensile strength at break MD	Mpa	ASTM D882	46.6 ± 4.01	41.0 ± 1.00
Tensile strength at break TD	Mpa		43.4 ± 2.45	37.0 ± 1.00
Tensile strength at yield MD	Mpa		17.3 ± 2.06	16.5 ± 0.50
Tensile strength at yield TD	Mpa		21 ± 0.70	567.5 ± 7.50
Elongation at break MD	%		531.7 ± 47.15	562.5 ± 12.83
Elongation at break TD	%		563.2 ± 33.68	537.5 ± 12.50
Elongation at yield MD	%		7.3 ± 0.55	13.5 ± 0.50
Elongation at yield TD	%		7.8 ± 0.51	13.5 ± 0.50
Oxygen permeability	Cc/m^2/day		≤ 450	≤ 0.1
Water vapour permeability	g/m^2/day		≤ 2	≤ 1

Experimental Procedure and Measurements

For the Infra-red pre-heat treatment, the optimum radiation intensity , and exposure time for heat treatment of bean seeds was assessed to obtain the best heat treatment which reduced the activity of trypsin inhibitor to the lowest value and the minimize level of fungal count in order to treat the rest of the seeds for the storage process.

The prepared films were formed into 10 kilogram capacity bags. The non-heat treated faba bean seeds, with an initial moisture content of 11.67% w.b., and the heat treated bean seeds, with an initial moisture content of 9.77% wet basis, were used to fill the produced bags. For eight months, the samples were kept in a naturally occurring storage chamber.

Measurements

Moisture content of faba bean seeds.

Moisture content of the bean seeds samples was determined using the conventional air oven method, as outlined in the American Association of Cereal Chemists (AACC, 2000). A total of 15 grams of bean seeds samples were subjected to a temperature of 105ºC for 72hours. The dried samples were reweighed using an electronic digital scale, and the moisture content was calculated as a wet basis (w.b. %)

Bulk temperature of faba bean seeds.

A one-point temperature meter model (AW SPERRY DM-8600, Taiwan) was used to measure the temperature. The sensing tip of the temperature meter was inserted into the bulk of the bean seeds until a stable reading was obtained.

Ambient air temperature and relative humidity

The ambient air temperature and relative humidity (RH) of the storage were measured using a temperature – humidity probe coupled to the meter model (Lutron, Model MS-7011)

CO_2 Concentration Analyzer

The concentration of carbon dioxide (CO_2) was measured on a monthly basis throughout the storage period using a carbon dioxide sensor (Gas Analysis- type VI GAZ "Box 121, France), The probe of the meter was inserted into the bags at different locations and the average of the readings were recorded for each experimental treatment.

Total Fungal Counts (cfu/g)

Total fungal count was measured according to the methodology of, Samson *et al*., (1996)

Total Protein Content

The total Nitrogen was determined by using micro kjeldahel method according to the method of AOAC, (1990). Total protein was calculated by multiplying the total nitrogen by 6.25

Trypsin Inhibitor (TIU/mg)

The trypsin inhibitor (TI) activity was assessed by incubating 50 µl of crude extract with 20 µl of commercial bovine trypsin (1 mg mL^{-1}) and incubating at 37 ºC for 15 min, by adopting the method given by Kakade *et al*., (1974)

Insect Count

The faba bean seeds were sieved and the weevils were counted according to (AOAC , 2000).

RESULTS AND DISCUSSION

Infrared heating of faba bean seeds.

Change of faba bean seeds moisture content

The change in faba bean moisture content as related to heating time during the infrared heating process is illustrated in Fig (2).

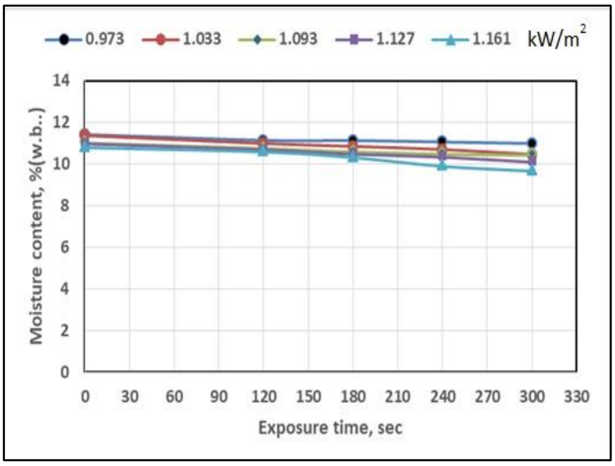

Fig. 2. Variation in the moisture content of faba bean seeds with exposure time.

The results show that the removed moisture of seeds increased with the increase of heating time under a specific radiation intensity, this is due to more energy absorbed by the bean seeds with longer exposure time and more water evaporated from the seeds compared to shorter heating time. In general, the final seeds moisture content at different levels of radiation intensity, ranged from 11.67 to 9.66% (w.b) respectively. Meanwhile the lowest level of moisture content (9.66% w.b) was obtained at radiation intensity of 1.161 kW/m^2 and exposure time of 360 sec, while, the highest level of moisture content (11.12% w.b) was obtained at radiation intensity of 0 .973 kW/m^2 and exposure time of 120 sec. Similar results were obtained by (Matouk *et al*., (2017) and Tharwat *et al*., (2023).

Change in seeds bulk temperature

The bulk temperature of seeds in relation to heating time is illustrated in Fig. (3). The figure illustrates how the bulk temperature of seeds climbed progressively over extended exposure times, starting lower in the early stages of the heating process. The heated bean seeds had a temperature range of 44.1 to 96.1 ºC. As shown in Fig. (3), at the maximum exposure time of 360 sec the final temperature of the seeds bulk approached 58.8, 67.3, 78.6, 87.6 and 96.1 ºC for the faba bean seeds heated at radiation intensity of 0.973, 1.033, 1.093, 1.127 and 1.161 kW/m² respectively.

While, the corresponding levels of seeds bulk temperature at the minimum exposure time of 120 sec were 44.1, 45.5, 52.3, 55 and 58.8 ºC respectively.

This means that, both radiation intensity and exposure time play an important role in the increase of seeds bulk temperature. The interactive effect of these two factors was reported by El-Kholy and Tharwat, (2008); Khamis, (2009); Sun, (2012) and Tharwat *et al*., (2023)

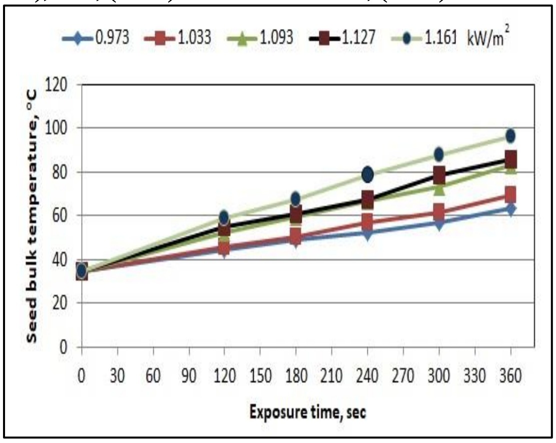

Fig. 3. Variation in the bulk temperature of faba beans in relation to exposure time.

Fungal count as affected by heat treatment

The variations in fungal count (colony-forming units per gram) in relation to radiation intensity across various exposure durations are illustrated in Fig. (4). The results unequivocally showed that, depending on the radiation intensity and exposure time, growing radiation levels tend to reduce the fungal load in faba bean seeds.

At the lowest radiation intensity of 0.973 kW / m² and the highest exposure time of 360 second, there was a drop in the overall microbial load count from 38 × 10^2 to 30× 10^2 cfu / g. In contrast, the overall microbial count exhibited a decline from 38× 10^2 to 14× 10^2 cfu / g under the highest radiation dose of 1.161 kW / m² and the highest exposure duration of 360 second. The above mentioned results reflected the positive effect of heat treatment on reducing fungal and microbial load on the surface of seeds. This load had an impact on the seeds' quality preservation and safe storage as well. as mentioned by Jun and Irudayaraj, (2003); Sawai *et al*., (2003); Sorour, (2006) ; Aboud *et al*., (2019); Matouk *et al*., (2017) and Tharwat *et al*., (2023)

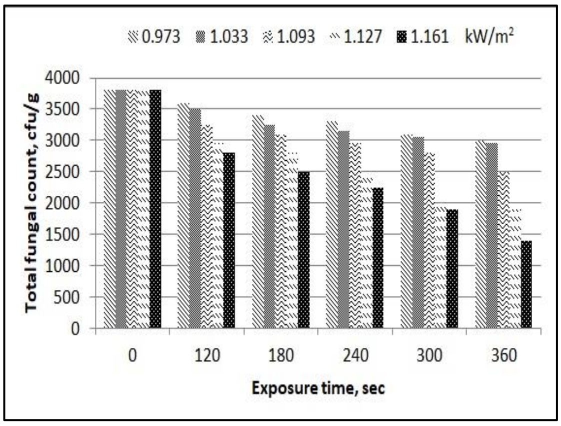

Fig. 4. Fungal colonies count at different levels of radiation intensity and exposure time.

Change of Trypsin Enzyme Inhibitor Activity TIU/mg

The levels of trypsin enzyme inhibitor activity, (TIU /mg) as related to levels of heat treatment of faba bean seeds are shown in Fig. (5). The results indicated that the greater the intensity of heating and the exposure time, the less the activity of the trypsin enzyme inhibitor .The levels of trypsin inhibitor activity of the heat treated bean seeds were ranged from 3.95 to 1.10 TIU/mg in comparison with 3.95 TIU/mg for the non-treated samples (fresh samples).At radiation intensity of 1.161 kW/m² and exposure time of 240 second, the minimum trypsin enzyme inhibitor of 1.11TIU/mg, was obtained.

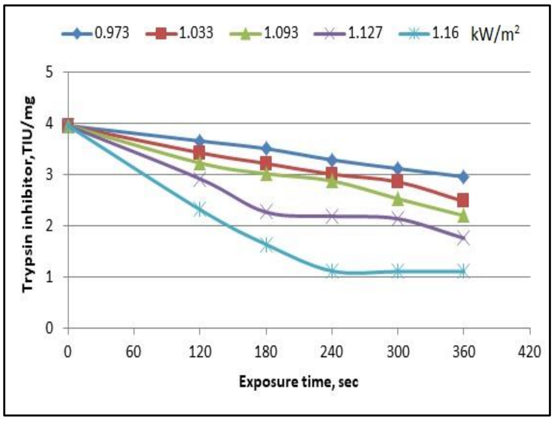

Fig. 5. Levels of trypsin inhibitor as related to radiation intensity and exposure time during the infra-red heating process.

The above mentioned results indicated that, the heat treatment reduced the trypsin enzyme activity by 72.15% at 1.161 kW/m^2 and 240 sec. This condition may be reflected on a noticeable reduction in cooking time and protein digestibility as mentioned by Mwangwela *et al*., (2007); Kayitesi *et al*., (2013); Fasina *et al*., (2001); Khattab and Arntfield, (2009).

In general, the Infra-red pre-heat treatment at 1.161 kW/m^2 for 240 sec was selected as an optimum pre-heat treatment for the storage process.

Storage experiments at different types of hermetic bags

The quantity of seeds prepared for storage was 480 kg, stored in a different types of hermetic bags and compared with the traditional burlap bags with capacity of 10 kg per bag, 240 kg of seeds were treated with Infra-red at 1.161 kW/m^2 for 240 sec as an optimum heat treatment and other 240 kg of seeds were stored without heat treatment. The whole storage period was 8 months. The average ambient temperature varied between 14.56 and 34.7°C, while the relative humidity ranged from 67 to74.1 % throughout the storage period.

Change of Seeds bulk temperature as related to storage period

Seeds bulk temperature as related to storage period is presented in Fig.(6). As shown in the figure, the seeds bulk temperatures showed a noticeable fluctuation during the storage period and were closely related to the temperatures of the atmosphere surrounding the storage bags over the period of storage. For the non-heated seeds, the recorded level of seeds bulk temperature ranged between 21.2°C and 38.1°C for the bags of type (1), and between 21°C to 38.1°C for the bags of type (2). Meanwhile the regular bags (burlap) recorded seeds bulk temperature ranged from 21.4°C to 38.1°C. Meanwhile the change of seeds bulk temperature of the heated faba bean seeds, also affected by the temperature of the ambient atmosphere surrounding the storage bags over the period of storage, and it was ranged between 21.2°C and 38.1°C for the bags of type (1) and from 21°C to 38.1°C for the bags of type (2), While in regular burlap bags recorded seeds bulk temperature ranged from 21.4°C to 38.1°C.

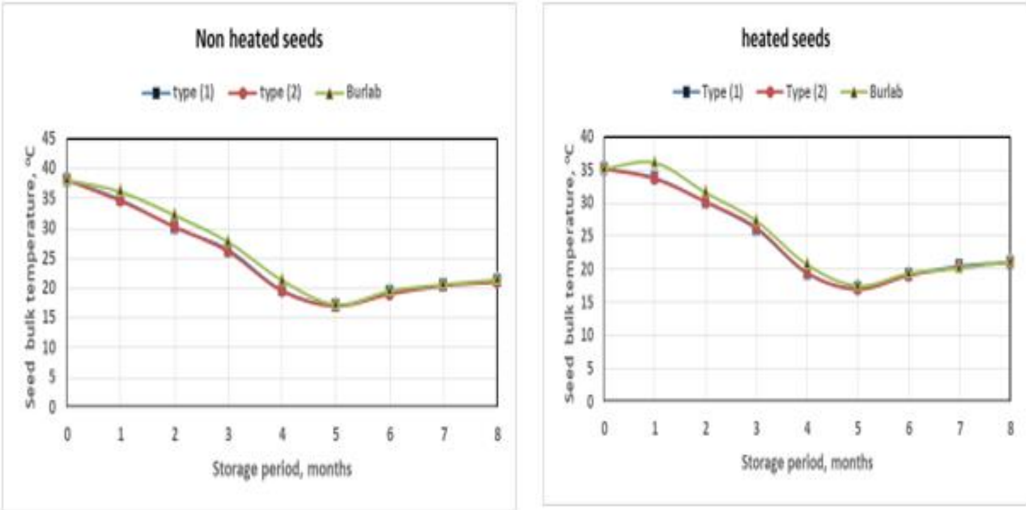

Fig. 6. Change of seeds bulk temperature, as related to storage period.

Change of seeds moisture content as related to storage period.

Moisture content (% w.b) of stored seeds as related to storage period (month) is presented in Fig. (7), As shown in the figure, there are several factors affecting the change of seeds moisture content during the storage period these factors including seeds initial moisture content, relative humidity in the storage environment, the presence of insects, storage fungi, and the seed respiration rate. According to the data shown in the Fig.(7), the moisture content of the non-heated faba bean seeds stored in the regular burlap bags showed a gradual decrease in moisture content in the first two months of storage and ranged from 11.67to 11.23% w.b. After that, there was a noticeable increase in the moisture content of seeds, reaching 13.01% (w.b). This increase in seeds moisture content may be attributed to high permeability of bags and the corresponding moisture absorption from the surrounding environment, the increase in seeds respiration rate and also to the moisture produced from the fungi and insect presented in the burlap bags.

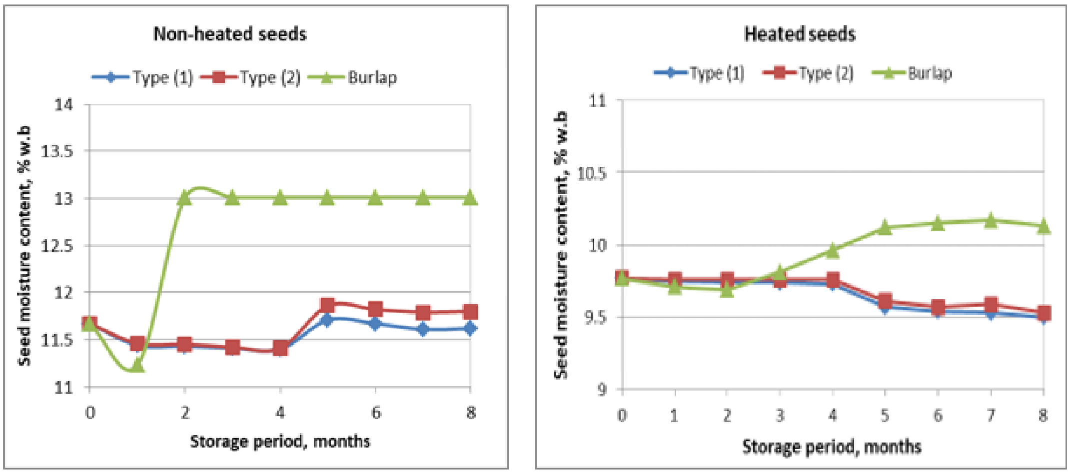

Fig. 7. Change of seeds moisture content , as related to storage period for the heated seeds and non- heated seeds stored in different types of bags.

While the corresponding results of the non-heated seeds stored in sealed hermetic bags Types (1) and (2) showed a marginal, limited increase in the moisture content of seeds which reflects the proper sealing of seeds which eliminate moisture absorption from the surrounding and the lower respiration rate of seeds. The results also show that, the non- heat treated seeds recorded higher levels of temperature and moisture content compared to the heat-treated seeds in all types of bags. This could be due to the higher respiratory activities of the non-treated seeds and the presence of some insects and fungi in the bags, While, the heat treatment led to seeds sterilization and reduced the rate of fungi and insect growth as recorded by Matouk *et al*., (2017) and Tharwat *et al*.,(2023).

Co_2 concentration.

The Co_2 concentration exhibited variability across different plastic materials and grain conditions, as depicted in Fig.(8), the findings indicate that, for the pre-heat treated stored seeds, the plastic bags of Type (2) exhibited high level of carbon dioxide concentration, with a rise from 0.3% to 13.9%. This was followed by the bags of Type (1) which showed a Co_2 rise from 0.3% to 12.6%. While, the burlap bags exhibited carbon dioxide varied from 0.3% and 0.4%. Meanwhile, the non-treated seeds stored in the plastic bags of Type (2) exhibited carbon dioxide level ranged from 0.3% to 14.5%, followed by the bags of Type (1), which showed a rise in Co_2 levels from 0.3% to 14.1%.

The concentration of Co_2 was seen to change depending on the type of hermetic materials and the condition of stored seeds. Also both fungi and insect count affected the level of Co_2 due to their respiration rate .Similar results were obtained by De Bruin, (2005); Matouk *et al*., (2017) and Tharwat *et al*., (2023).

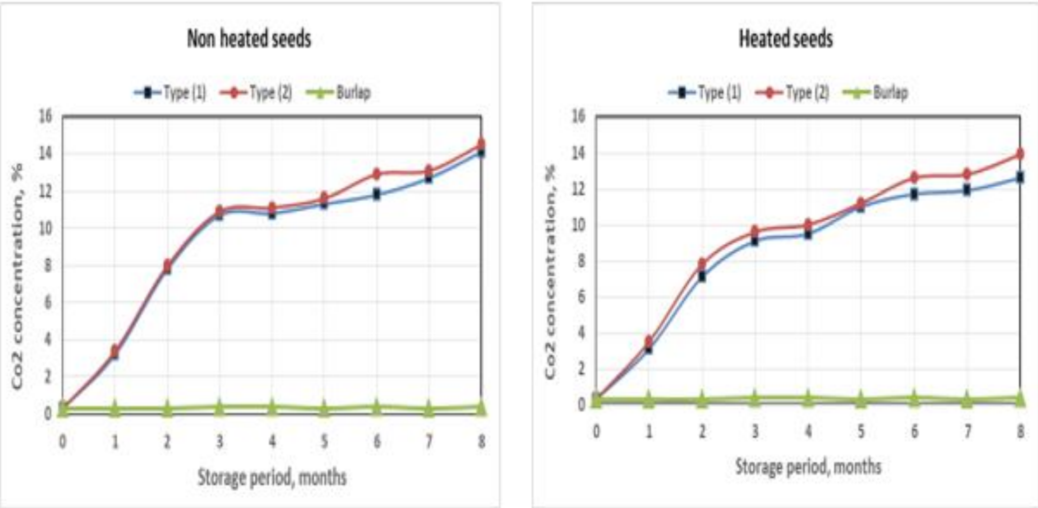

Fig. 8. Co_2 concentration (%) as related of bag types and storage period.

Trypsin inhibitor activity TIU/mg

As shown in Fig. (9), the level of trypsin content slightly increased, for the non-heat treated seeds stored in the hermetic bags type (1) and (2), while it was increased in higher rate for the seeds stored in the regular burlap bags. For the non-heated seeds the level of trypsin inhibitor increased from 3.95to 4.18 TIU/mg for the seeds stored in type (1) bags and from 3.95 to 4.16 TIU/mg for type (2) bags, while it was increased from 3.95 to4.46 TIU/mg in the regular burlap bag. However, For the heated seeds, the level of trypsin inhibitor activity were decreased from 1.11 to 1.00 TIU/mg for the bags type (1) bags, and from 1.11 to 1.00 TIU/mg for type (2) bags, while it was increased from 1.11 to1.17 TIU/mg for the regular burlap bags.

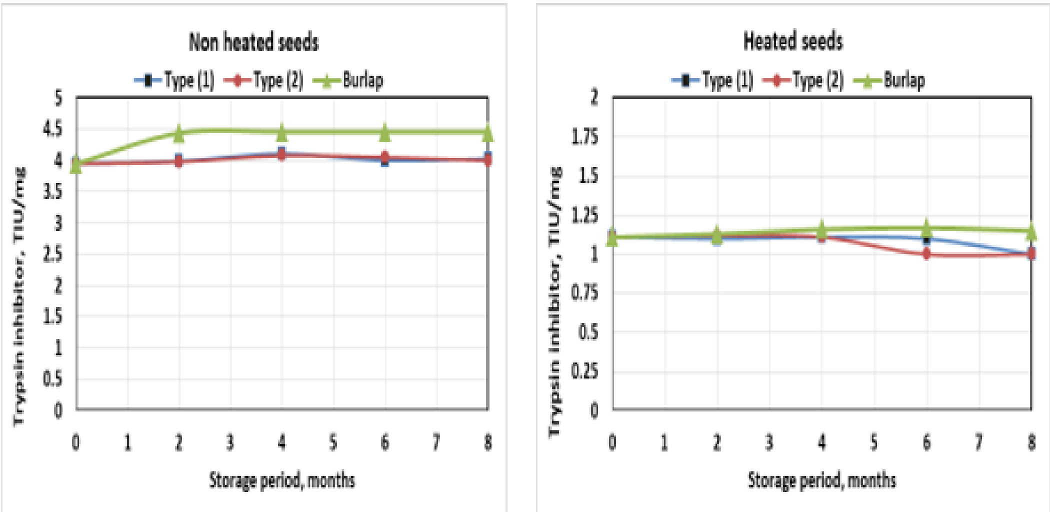

Fig. 9. Change of Trypsin Inhibitor as related to Storage period.

The above mentioned results revealed that, the trypsin inhibitor level was mainly affected by heat treatment. However the type of storage bags not affecting the pre-level of trypsin along the storage period as reported by Mwangwela *et al*., (2007); Kayitesi *et al*., (2013); Fasina *et al*., (2001); El-Niely, (2001); Khattab and Arntfield, (2009).

Protein content (%)

The variation in the protein percentage of faba bean seeds kept in various kinds of storage bags in relation to the duration of storage is displayed in Fig. (10). The protein percentage of the non-heated seeds varied from 18 to 21.43%, 18 to 21%, and 18 to 21.62% for the seeds stored in type (1), type (2), and conventional burlap bags, respectively. In addition, for the heated seeds stored in type (1), type (2), and conventional burlap bags, respectively, the protein percentage varied from 16.43 to 18.31%, 16.43 to 18.12%, and 16.43 to 21.37%.

Overall, the kind of storage bags had no effect on the protein percentage, however heated seeds showed a slightly lower proportion of protein than heated seeds due to denaturation of protein due to heat treatment as mentioned by Sikorski, (2001); Bellido *et al*., (2006); Krishnamurthy *et al*., (2010); Dissanayake *et al*., (2013); Padmashree *et al*., (2016) and Matouk *et al*., (2017).

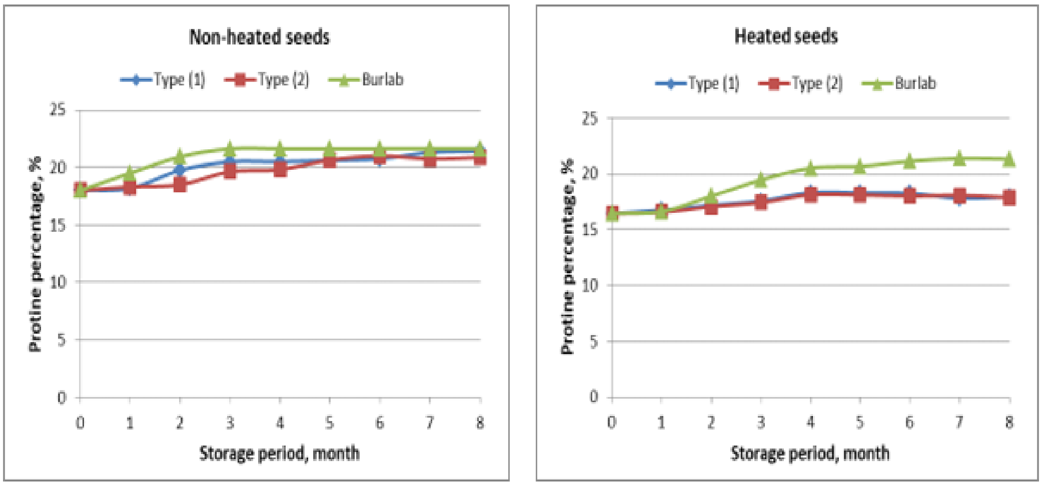

Fig. 10. Change of protein percentage for the heated and non-heated seeds as related to storage period.

Total Fungal Count, (Cfu/g)

The data of fungal colonies count indicates that the presence of fungi in the seeds is influenced by both, heat treatment and level of Co_2 inside the bags.

According to the data presented in Fig. (11), the non-heated seeds exhibited a fungal count of 180×10^2, 98×10^2, and 690×10^2 cfu /g for type (1) and type (2) bags, respectively. However, the burlap bags exhibited a dramatically increased of fungal count, which approached 690×10^2 cfu /g. On the other hand, the heated seeds showed lower fungal count of 16×10^2, 10×10^2, and 108×10^2 cfu/g for type (1), type (2) and the burlap bags, respectively.

This implies that both types of hermetic bags exhibited lower count of fungal counts were effective in suppressing fungal development during the storage period. Nevertheless, the presence of anti-fungi substances in the bags type (2) showed a relative effect on fungal growth and reduced the fungal count by 68.75% from the initial storage level, in comparison by 50% for the bags type (1) This results supported by the results obtained by Jun and Irudayaraj, (2003); Sawai *et al*., (2003); Sorour, (2006); Aboud *et al*., (2019); Matouk *et al*., (2017) and Tharwat *et al*., (2023).

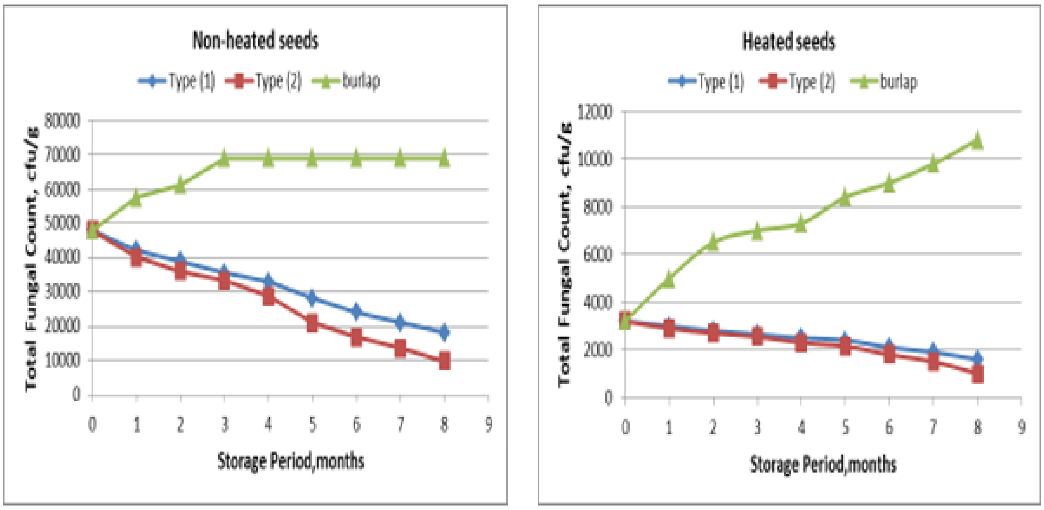

Fig. 11. Total fungal count as related to bags types and storage period

Insect count as related to storage period

Table (2) presents the insect count for different experimental treatments. As shown in the table, both types of hermetic bags show zero level of insects for both heated and non-heated seeds, while the burlap bags exhibited a dramatic increase specially for the non-heated seeds which recorded 850 insect/kg following the period of storage, a dead insects were appeared in the non-heated seeds stored in the hermetic bags, while the heated seeds showed zero insects.

Table 2. Insect count (insect/kg) for the heated and non-heated seeds in relation to storage duration (months).

storage period, months	Non-heated seeds			Heated seeds		
	Type (1)	Type (2)	burlap	Type (1)	Type (2)	burlap
0	0	0	0	0	0	0
1	0	0	60	0	0	0
2	0	0	460	0	0	2
3	0	0	650	0	0	5
4	0	0	850	0	0	10
5	7(dead)	3(dead)		0	0	31
6	9(dead)	7(dead)		0	0	39
7	10(dead)	8(dead)		0	0	45
8	14(dead)	10(dead)		0	0	55

According to the aforementioned findings, heat treatment stopped insect eggs from inviting seeds into the hermetic bags, and the high Co2 content inside the bags inhibited bug development. In general it could be conducted that, seeds storage in hermetic bags is a promising method for minimization of fungicides in seeds storage. This concept supports the environment and health protection as reported by Minagri, (2006); Villers et al., (2008); Khamis, (2009); Villers et al., (2010); García-Lara et al., (2013); Matouk et al., (2017) and Tharwat et al (2023).

CONCLUSION

Infrared heating at a level of 1.161 kW/m^2 and an exposure time of 240 second was found to be the best heat treatment for faba bean seeds, prior to the storage process. Also, Storage of faba bean seeds in the hermetic bags type (2) is recommended for safe storage and quality retention of the stored seeds.

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المعاملة المبدئية للفول البلدي بالأشعة تحت الحمراء لخفض نشاط مانعات التغذية والتخزين الآمن بأنواع مختلفة من الأجولة البلاستيكية النوعية

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الملخص

أجريت الدراسة الحالية لاختبار وتقييم تأثير المعاملة الحرارية المسبقة بالأشعة تحت الحمراء لبذور الفول البلدي متبوعة بالتخزين في أنواع مختلفة من الأكياس محكمة الغلق على التخزين الآمن والحفاظ على جودة بذور الفول البلدي المخزنة. تم إجراء المعاملة الحرارية المسبقة بالأشعة تحت الحمراء تحت خمسة مستويات مختلفة من شدة الإشعاع (٠,٩٧٣ ، ١,٠٣٣ ، ١,٠٩٣، ١,١٢٧، و ١,١٦١ كيلو وات / م٢) وخمسة مستويات مختلفة من زمن التعرض (١٢٠ و ١٨٠ و ٢٤٠ و ٣٠٠ و ٣٦٠ ثانية). تضمن إجراء التجربة اختبار نوعين مختلفين من الأكياس البلاستيكية محكمة الغلق (النوع -١) ١٥٠ ميكرون بدون مادة مضادة للفطريات، (النوع -٢) ١٢٠ ميكرون مع مادة مضادة للفطريات والأجولة الخيش التقليدية كمعاملة تقليدية لكلا النوعين - تم تخزين البذور المعاملة حرارياً والبذور غير المعاملة لمدة ٨ أشهر. وتضمنت أسس تقييم البذور بعد المعاملة الحرارية المسبقة التغير في المحتوي الرطوبي للبذورودرجة حرارة كتلة البذور ونشاط مثبط انزيم التربسين العد الفطري كما اشتملت قياسات تجارب التخزين علي المحتوى الرطوبي للبذور، ودرجة حرارة كتلة البذور، وتركيز ثاني أكسيد الكربون، ونشاط مثبط انزيم التربسين، ومحتوى البروتين، والعد الفطري والحشري.توصلت النتائج إلى أنه يوصى بالمعالجة الحرارية المسبقة بالأشعة تحت الحمراء لبذور الفول البلدي بشدة إشعاع ١,١٦١ كيلو وات / م٢ وزمن تعرض ٢٤٠ ثانية، يليها تخزينها في أكياس بلاستيكية محكمة الغلق مع مضادات الفطريات (النوع -٢) بشكل آمن والحفاظ على جودة بذور الفول البلدي.

الكلمات الدالة : الفول البلدي – التخزين المحكم – المعاملة الحرارية – نشاط مثبط انزيم التربسين – الاشعة تحت الحمراء.