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Improvement of Jute Packages to Resist Insects during Storage of Bean Seeds

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Abstract

The most important factor for obtaining good fiber is the strength of adhesion between fiber and polymer. Jute bags were treated with aqueous extracts from two insecticidal plants, *Chenopodium ambrosioides* and *Lantana camara*, to reduce damage to stored bean seeds by *Acanthoscelides obtectus*. The hydrophobic nature of jute bags makes it difficult to adhere to plants extract due to the presence of hydroxyl groups in various constituents of jute and treatment of jute bags with sodium hydroxide (5%) alleviate such problem. Infested bean seeds were kept in small treated jute bags (infestation rate 1%) and stored for six months in order to evaluate the protection efficiency of the fabric against damage to bean seeds. Alkali jute bags were treated with different concentrations of *L.camara* and *C. ambrosiodes* extract (10, 20, 30, 40%), The least percent of bean seed damaged 2.5% was recorded for alkali jute bags treated with 40% *L.camara* extract.

Keywords: Jute bags; Storage; Plant extract; Bag treatment; Agriculture crops; Seed damage

Introduction

Jute is a soft vegetable fiber from the plant can be spun into coarse strong yarns. It has (58-63%) of cellulose, which is produced by jute stem. It is used extensively for fabrics in the packaging of agricultural and industrial commodities, which require sacks and wrapping. It is grown in hot moist climates and is prevalent in India and Pakistan, although China is now a large producer. Thus jute is the most friendly fiber starting from seed to fiber; it is 100% bio-degradable and recyclable [1].

Jute exhibit many advantageous properties for use as reinforcement materials for composites, they are low-density materials yielding considerably lightweight composites with highly specific properties. Natural fibers also offer significant cost advantages and benefits associated with their processing, relative to synthetic fibers. Furthermore, they are a highly renewable resource, which reduces the dependency on petroleum oil [2].

Mohanty et al. [3] prepared the jute fabrics by washing it with 2% detergent solution at 70°C for 1 h, then washed with distilled water and finally dried in a vacuum oven at 70°C. The detergent washed fabrics were dewaxed with a 1:2 mixture of alcohol and benzene for 72 h at 50°C, followed by washing with distilled water and drying. The dewaxed/defatted fabrics were treated with 5% NaOH solution for 30 min. at 30°C, then washed overnight in running tap water and then with distilled water followed by oven drying to obtain alkali treated fabrics.

Plant fibre composites combine good mechanical properties with low specific mass. However, their high moisture absorption, poor wettability and insufficient adhesion between untreated fibre and polymer matrix lead to debonding at fibre–matrix interface [4]. To improve the properties of their composites, natural reinforcing fibres can be modified by physical and chemical methods [5-7]. Plant fibres must exhibit a compatible surface morphology for the development of a coherent interface with matrix polymers but because of the surface impurities, present in plant materials the development of a good fibre–matrix interface is impaired [8,9]. In order to make use of the good physical and structural characteristics of the fibers they are treated with chemicals such as caustic soda to modify surface topography and the fine structure. Partial removal of lignin and hemicelluloses on the alkali treatment of cellulose fibres was reported by [10].

Burchids are a major threat to stored legume grains in west and central Africa, and infestations by the most prominent species (*Ancanthescelides obtectus*) on common beans are responsible for grain losses estimated at 20-60%, [11,12] Such losses are determined to resource –poor farmers since grain legumes constitute their major source of cheap and high quality dietary protein [13-15].

The main causes of loss in storage systems have been discussed by many authors [16-18]. Many of the agents of the loss are interrelated (e.g. under-drying or wetting leads to mold and mites, many mites and some insects feed on molds. Insects spread fungal spores, and insect activity leads to increased moisture content).

The loss agents generally fall into three classes: unavoidable (e.g. weather), human- induced (e.g., contamination, spillage, theft), and pest-induced (e.g., insects, mites, rodents).

More than species of insects can occur in stored grain products. Fortunately, cold weather is very effective in minimizing insect infestations. Worldwide, literally hundreds of species of insects and mites occur in stored grain. About, 5% of the world's grain is destroyed in store by insects and much more than this is partially spoiled. Many purchasers will not accept infested grain. Finally, mites and some insects can induce allergies and cause digestive upsets in farm animal,

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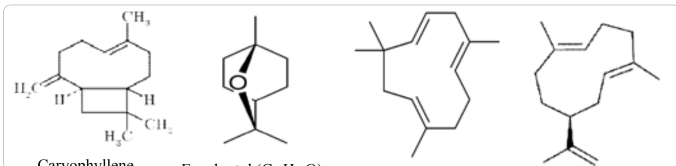
[19]. Even though control of these insects in long-term storage can be achieved by synthetic insecticides [20]. The widespread protection practice at the farmer level in these regions remains that of mixing grains with locally available natural substances such as wood-ash, fresh or dried plant leaves (Chiranjeevi, 1991; Rajapakse and van Emden, 1997) which they consider less hazardous and of no cost.

To obtain the aqueous extract from *L.camara* and *C. ambresidios* plants, 10 g of leaves of the plant were washed thoroughly with tap water and ground using a mixer grinder to make a paste; this was then diluted with 100 ml of water, filtered through muslin cloth, and used immediately upon preparation for bag treatment as a 10% aqueous extract (w/v). To obtain plant powders, leaves were dried in an oven at 40°C for 7 days, finely ground, then mixed with seeds at the rate of 4% (w/w) [14,15].

The main essential oils in *L. camara* are, Caryophyllene (16.37%), euealyptol (10.75%), α-humelene (8.22%), and germaerene-D (7.41%) were present in major amounts and eontributed 42.75 percent of the total (Dua et al. 2010) Figure 1.

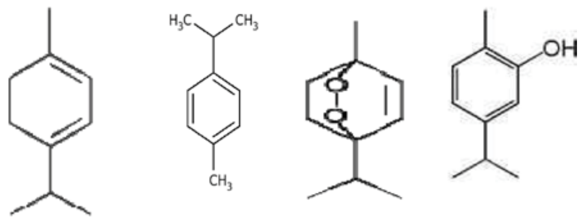
The chemical constituent analysis of the leaf oil. The main compounds of the oil were identified as a-terpinen (37.6%), cymol (p-cymen) (50.0%), ascaridole (3.5%) and carvacrol (3.3%) [13] Figure 2.

Koona et al. [14,15] stated that infested and uninfested bean grains were kept in small jute bags (infestation rate 1% and 2%), then mixed with the powder from the stem bark of Scorodophloeus zenkeri at the 2, 4 and 6% doses (w/w) and stored for 6 months in order to evaluate the protectant effect of this plant substance against damage to grains by the bean beetle Acanthoscelides obtectus. There was a significant treatment effect, the percentage of grain damage increasing with the infestation level. There was a significant negative relationship between the level of grain damage and the treatment dose. The potential for using this tropical plant at the farmer level in long-term storage of bean grain is discussed.



Caryophyllene ($C_{15}H_{24}$) Euealyptol ($C_{10}H_{18}O$) α-humelene (C15H24) Germacrene ($C_{15}H_{24}$)

Figure 1: The main essential oil in L.camara extract.



Terpinenes (C10H16) Cymene (C10H14) Ascaridole (C10H16O2) Carvacrol (C10H14O)

Figure 2: The main essential oil in *C. ambrosioides* plant extract.

Koona and Koona [21] stated that jute bags impregnated with aqueous extracts from two insecticidal plants, Chenopodium ambrosioides and Lantana camara, were used to reduce damage to stored legume seeds by two major bruchid insect pests, Acanthoscelides obtectus and Callosobruchus maculatus, it was compared with a direct seed-treatment method using plant powders. In the first method bags were treated with a 10% concentration of the aqueous plant extract and filled with bean or cowpea seeds, whereas in the second method seeds were thoroughly mixed with leaf powder from the same plants at the rate of 4% (w/w). The results show that bag-treatment method significantly reduced seed damage compared with the untreated control after 6 months of storage. The percent damage controlled by impregment bags method was significantly higher than the damage recorded in the seed-treatment method.

The objective of the present study is to treat jute bags with NaOH to improve interfacial adhesion of jute fiber, treat jute bags with the extract of *Lantana camara* and *Chenopedium ambrosiodes* to reduce the damage of bean seeds during storage.

Experimental

Materials

Jute packages were supplied by the public company of jute-Egypt. *L. camara* and *C. ambrosiodes* plants used in this research were collected from Faculty of Agricultural Cairo University in December.

Jute packages treatment

Jute bags were washed using 2% detergent solution at 70°C for 1 hr., then washed with distilled water and finally dried in a Laboratory oven at 70°C. The defatted fabrics were treated with NaOH (5%) solution for 30 min. at 30°C then washed thoroughly with distilled water to obtain alkali treated fabrics.

Preparation of plant extract

Leaves of *L. camara* and *C. ambrosiodes* were washed and dried naturally on laboratory benches at room temperature (26-30°C) for 5 days until they were fully dried. Furthermore, four concentrations of each plant namely 10gm, 20gm, 30gm, 40 gm of plant leaves were applied separately in 100ml boiling water for 10 min. Preparation was made at concentration (10, 20, 30, 40 wt/v %) and were filtered through a Whatman filter paper No.1 and stored at (-20°C).

Storage of bean seeds

Clean healthy and uninfested bean seeds used for this study were obtained from the local market, its type was (Giza 3). Uninfected bean seeds had no holes and kept at -18°C for two weeks to ensure that they were not infested, each treated jute bag was filled with 400 uninfested bean seeds to which 4 infested bean seeds were added making an infestation rate of 1%, the bags were shaken thoroughly to ensure mixing of seeds. Bags were divided into groups according to different treatments. Jute bags were conducted in duplicate and average values reported. All bags were then placed on shelves in the laboratory 25°C in completely randomized design (Motoko, 1995). The storage period of seeds was 6 months; Data was collected every month on the number of damaged grains. A weevil perforation index (Koona et al., 2007) was calculated as:

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$$WPI = \frac{(\ \%\ treated\ seed\ perforated\ )\ 100}{(\ \%\ control\ seeds\ perforated\ +\ \%\ treated\ seeds\ perforated\ )} \quad (1)$$

A WPI>50 indicates a negative protectant effect, whereas a WPI<50 indicates a positive effect or a decrease in infestation.

Results and Discussion

Damage by *A. obtectus* to bean seeds stored in treated jute bags

The most important factor for obtaining good fiber is the strength of adhesion between fiber and polymer. Due to the presence of hydroxy and other polar groups in various constituents of jute, the moisture absorption is high, which leads to poor wettability and weak interfacial bonding between fibers and more hydrophobic matrices. Therefore, in order to develop composites with better mechanical properties, it is necessary to impart hydrphobicity to the fibers by suitable chemical treatments. Such surface modification of jute would not only decrease the moisture absorption, but would increase the wettability of fibers with polymer and the interfacial bond strength both critical value for obtaining better mechanical properties of the fiber [3].

- In the present work, we have investigated the effeThe percent of seed damaged stored in alkali treated jute bags (5% NaOH).
- The percent of seed damaged stored in jute bags treated with different concentrations of *L.camara* extract.
- The percent of seed damaged stored in jute bags treated with then different concentrations of *C. ambrosiodes* extract.
- The percent of seed damaged stored in jute bags treated with (5% NaOH) then different concentrations of *L.camara* extract.
- The percent of seed damaged stored in jute bags treated with (5% NaOH) then different concentrations of *C. ambrosiodes* extract.

Jute bags treated with plant extract

Figures 3 and 4 that jute bags treated with different concentrations of *Lantana camara* extract (10, 20, 30, 40%) reduce the percent of seed damage from 4.24% to 2.5% as concentration of *L. camara* increased, while jute bags treated with different concentrations of *C.ambrosioides* extract decrease percent seed damaged decrease from 5.25 to 3%, this may be due to that odors from both plants extract were capable of suffocating storage insects in jute bags. This mode of action would guarantee maximum grain protection even in larger containers such as the full-sized 50-100kg bags commonly used for grain storage by farmers as previously discussed [22,23].

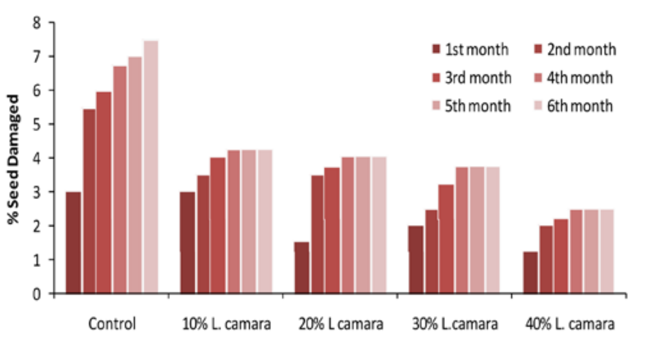

Figure 3: Damage of bean seeds stored in jute bags treated with different concentrations of *L. camara* extract (10, 20, 30, 40%).

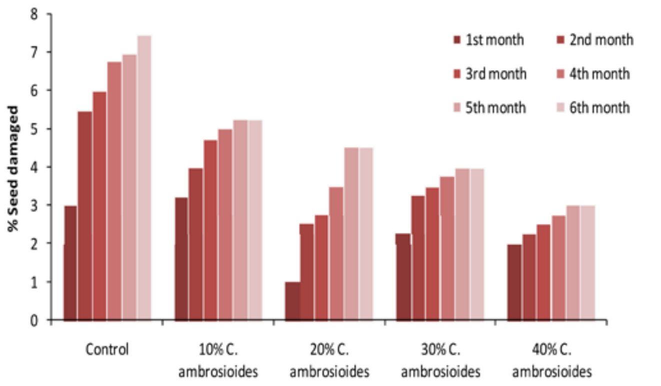

Figure 4: Damage of bean seeds stored in jute bags treated with different concentrations of *C.ambrosioides* extract (10, 20, 30, 40%).

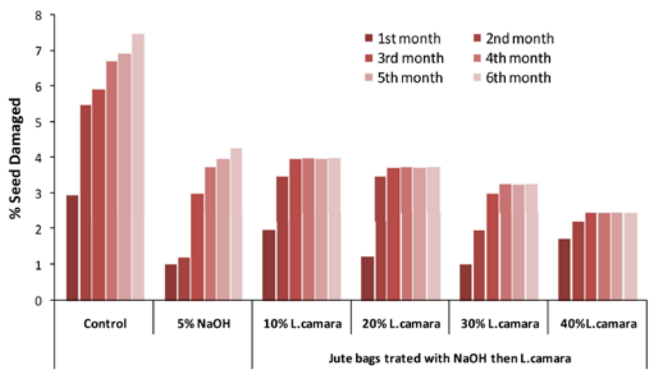

Figure 5: Damage of bean seeds stored in alkali treated jute bags (5%NaOH) then treated with different concentrations of *L.camara* extract (10, 20, 30, 40%).

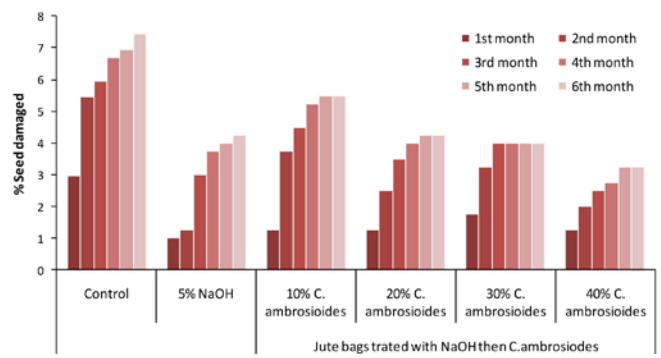

Figure 6: Damage of bean seeds stored in alkali treated jute bags (5%NaOH) then treated with different concentrations of *C.ambrosioides* extract (10, 20, 30, 40%).

Jute bags treated with NaOH then plant extract

Alkali treated bags (5% NaOH) with different concentrations of *L.camara* extract (10, 20, 30, 40%) reduce the percent of seed damaged as shown in Figure 5. The results show that the highest percent of seed damaged was recorded on control bags (7.5%), while the least percent was recorded on alkali treated bags with 40% *L.camara* extract (2.5%)

Treated jute bags	Total No. of seeds	damaged seeds	Undamaged seeds	% seed damaged	WPI
Control	400	30	370	7.5	
5% NaOH	400	17	383	4.25	36.17
10% L.Camara	400	17	383	4.25	36.17
20% L.Camara	400	16	384	4	34.78
30%L.Camara	400	15	385	3.75	33.33
40%L.Camara	400	10	390	2.5	25
Alkali treated jute bags (5%) then different concentrations of L.Camara					
10% L.camara	400	16	384	4	34.78
20% L.camara	400	15	385	3.75	33.33
30% L.camara	400	13	387	3.25	30.23
40% L.camara	400	10	390	2.5	25
Alkali treated jute bags (5%) then different concentrations of C. ambresidios					
10% **C. ambresidios**	400	19	381	4.75	38.78
20% **C. ambresidios**	400	14	386	3.5	31.82
30% **C. ambresidios**	400	14	386	3.5	31.82
40% **C. ambresidios**	400	13	387	3.25	30.23

Table 1: The weevil perforation index for bean seed damaged stored in treated jute bags.

as shown in Figure 5, this may be due to that alkali treatment improves the adhesive characteristics of fiber surface by removing natural and artificial impurities thereby producing a rough surface topography. The results confirmed that a stronger adhesion degree was obtained for composite jute strands probably due to the major number of hydrogen bonds between the components [3].

Figure 6 shows that the percent of seed damaged decrease as the concentration of *C.ambrosioides* extract increase. The highest percent of seed damaged was recorded on control bags (7.5%); while the least percent was recorded on alkali treated bags (5% NaOH) with 40% *C.ambrosioides* extract (3.25%)

Table 1 shows the weevil perforation index (WPI) of all rates of treated bags indicated a positive effect ranging between 16 and 46 all being less than 50. The least WPI was recorded 16 for jute bags treated with 5% NaOH then 40% *L.Camara* extract. WPI was calculated according to equation (1).

Conclusion

Jute fibers are considered to be the most promising material because of its wide commercial availability in the required form and low cost. Jute bags treated with sodium hydroxide, 5% and plants extract (*L.camara* and *C.ambrosioides*). The results demonstrate that jute bags treated with sodium hydroxide and plant extract were able to reduce the percent of seed damaged of bean seeds during storage.

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