FABRIC FINISHES: UPGRADING JUTE BAGS TO PROTECT LEGUMES FROM DAMAGED BY PESTS DURING STORAGE

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ABSTRACT

Communal farmers were identified as the major producers of nyemba seeds in Zimbabwe but were facing challenges on storage. Polythene bags posed the problem of degradation by mildew and mites as well as rancidity while with jute bags; the problem of weevil infection was encountered. An experiment was carried out to see if jute bags with a special finish of aqueous extracts from an indigenous plant 'Lantana Camara' would reduce the damage of the seeds by weevils. The fabric finish was applied to jute fabric that had been treated with 5% sodium hydroxides to make the adherence of the plant extract easier. Two different concentrations of the insecticidal finish (20% and 40%) were applied to the jute fabric. The fabric was then sewn into four small bags into which five hundred nyemba seeds were packaged in each, 1% of the seeds was infected with weevils and stored for twelve months. The 40% fabric finish concentration was recorded to have the least damage of the seeds (2.4%) after a period of twelve months. It was therefore concluded that the insecticidal fabric finish can significantly prolong the storage of nyemba seeds in jute packaging with minimum damage. The method was found safe, and environmentally friendly, affordable, and accessible to most of the farmers. It was recommended that the farmers consider using jute bags to which the fabric finish has been applied; the method be tried with other seeds used and grains; the process be commercialised since it contributes significantly to food security; and that further research focuses on trying the finish on other fabrics used in food packaging.

Keywords: Fabric finish, Weevil Perforation Index, jute, polymer, muslin cloth, rancidity

INTRODUCTION

Fabric finishing entails the physical or chemical application done to a textile fabric with the aim of improving and/or influencing its performance during use. Barb (2009) proposes that a fabric finish may be applied in the form of a polymeric film deposited on the surface of the fabric. This realisation inspired the researcher to think of how best the method can be incorporated in coming up with a solution to the problem identified in this study. It was however not adopted as is due to fear that the film might peel off and contaminate the stored seeds.

Nyemba is a small type of seed legume grown in Southern Africa. Legumes, also known as pulses are plants that bear fruits inside a pod. The fruits are usually seeds such as beans, peas, clover, lentils and nuts and are of high nutritive value since they are a good source of vegetable protein, hence the major source of the nutrient in vegetarian diet. They are also an excellent source of dietary fibre, low in fat; most of them provide most of the micronutrients required by our bodies (Assaf, 2007 and Raatz, 2007). In Zimbabwe, nyemba is cultivated at a small scale by communal farmers especially those in agricultural regions 4 and 5 where the rainy season is usually short. Nyemba is a relatively short season crop that requires very little fertilizer for one to realise a meaningful harvest (Waugh, 2011). It is therefore necessary to

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ensure that after harvest, the seeds are stored appropriately in such a way that they are protected from damage by pests. In support to this, Kenneth and Hellen Vaang (2012) propound, "The purpose of any grain storage facility is to prevent grain quality loss from weather, wind and moisture; rodents, birds, insects and micro-organisms".

According to Fellows (2002), food packaging is of great significance in that it aids food distribution, that is, the process becomes faster, easier, and more reliable. This will in turn help reduce malnutrition. It also reduces post harvest losses, thus allowing food producers to increase their outcome. The selection of materials for use in food packaging depends mainly on their availability and cost, jute bags were found to be readily available to the farmers since they can get them from the local market at an affordable price.

The farmers store the nyemba seeds in small granaries while packaged in either jute or polythene bags. The challenge they usually face is that of damage by pests especially weevils if in jute bags or by mildew and mites or rancidity if in polythene bags. Since their harvest is usually before the end of the rainy season, the weather will be very humid and conducive to the development of mildew. The damage usually occurs within a couple of weeks after storage or even before harvest in some cases. The farmers are aware of chemical insecticides but are not comfortable to use them since they distort the taste and flavour of the nyemba seeds that are usually cooked without further processing. They are also afraid of side effects that could result from the consumption of food preserved with chemicals (Champ and Dyte, 1976). The researcher therefore thought of how best the jute bags can be improves so that the damage of the seeds by weevils may be reduced. The aim was to come up with a more durable technique for storing seed legumes without excess loss.

The researcher thought of intervening through the use of the textile fabric commonly used in food packaging since the focus is on the study of textiles. A study by the Schumacher Centre for Technology however condemns the use of textile containers in food packaging, poor gas and moisture barrier properties as well as poor aesthetic value were cited as major weaknesses. Jute fabric however was still found most suitable for the storage of seed legumes despite all the allegations against the use of cellulose fibres, the reasons will be explained later in this study.

As a soft, fine and lustrous natural cellulose fibre, jute is obtained from the stem of the corchorous plant. It is mainly grown in India, Bangladesh, and Thailand, and processed into fabric in Asia, United States of America and in Scotland (Tortora, 1987). The fibre has been in use since the birth of civilisation but was not of any economic importance until towards the end of the eighteenth century as propounded by Roy, Charlerjee and Gupter (2001). It has however become one of the most widely used fibres world-wide especially in food packaging because of its durability, versatility, low cost and biodegradability, hence Pan, Day and Kumar (2004) assert that it is one of the most affordable natural fibres with a variety of uses.

In the U. S. Jute Bag Advocacy (2012), it is pointed out that jute exhibits many positive properties which include reinforcement materials for composites due to its low density (1.5g/cm^3), the material therefore yields considerably light weight composites. Jute fibres are 100% biodegradable and recyclable, they are therefore environmental friendly. This contributes towards the durability of the resultant fabric. As natural fibres, jute fibres offer significant cost benefits that are associated with their processing when compared with synthetic fibres. Furthermore, they reduce dependency on petroleum oil because they are renewable (Elsevier, 2002).The natural raw materials for jute fabric are very flexible and resist tearing up to very significant levels as discovered by Karmaka (1999). Their hygroscopic nature permits any excess moisture in stored seeds out of the packaging, thus protecting them from damage by mildew. They however need adequate aeration till the seeds are completely dry.

The combination of good mechanical properties with low specific mass makes the jute fibres very suitable for packing dried seeds. They however have some challenges which render them incompetent as pointed out earlier on. These include inadequate adhesiveness of polymers within the fibre which may result in de-bonding at fibre matrix interface and permitting entrance and breeding of pests inside the packaging. It is therefore necessary to modify the surface topography and the fine structure of the fibre in an effort to minimise food loss due to storage systems. This is done with cognisance of the fact that good packaging must keep the contained product clean by providing a barrier against dirt and other contaminants such as chemicals and pests (Kenneth and HellenVaang, 2012).

Pest induced food loss may be minimised by applying a fabric finish that discourages the pests from passing thought the bag surface and by keeping the stored food in a cool, dry place. The usual seed protection practiced by communal farmers in Zimbabwe at their own level is that of mixing the seed with natural substances which include leaves or ashes as recommended by Ivbijaro (1984) to suffocate the pests. This is usually as a result of their failure to afford commercial and/or synthetic insecticides and also their consideration of natural ones as they are less hazardous and easily accessible at minimal or no cost. In support of this, research by Adedire and Ajayi (1996) proved that synthetic insecticides can induce allergies and also cause digestive problems. In Zimbabwe some of the communal farmers follow this practice mainly because they cannot afford the synthetic pesticides.

THE PROBLEM

Communal farmers in Mberengwa District in the Midlands Province of Zimbabwe grow amongst other crops, nyemba (a small type of seed legume in the bean family grown in Southern Africa) since it is one of the crops that can strive to maturity with minimal rainfall. Mberengwa District falls under Rainfall Region 4 according to Agricultural classification of rainfall patterns in Zimbabwe. This Region receives very little rainfall and experiences short rainy season therefore short term and drought resistant crops such as nyemba are most ideal. This type of legume is highly nutritious and happens to be one of the most common sources of plant protein in the area being studied.

The farmers usually keep enough of the seed legume for their own consumption as well as for sale later in the year till the next harvest (± 1 year). Their major challenge is safe storage for the crop. They are usually able to keep the seeds reasonably free from infestation by pests for a period of two to four months, the period may however be prolonged to six months by the use of chemical pesticides. Most of them use natural control measures such as mixing the seed with leaves, ashes and twigs from plants they believe to scare off pests but these are all short lived (2-4 months). Lantana Camara is one of the plants they use but besides the short time effect, it takes time to clean the seeds before consumption. After treatment, they store the nyemba seeds in their granaries packed in jute, polyester or polythene bags. With jute bags the beans quickly develop weevils; as for polyester and polythene bags, there is the issue of mildew, mites and rancidity. It is against this background that the researcher found it necessary to carry out a study on how fabric finishing using materials the community is used to, can be applied to increase the storage life of the nyemba seeds.

OBJECTIVES

The following objectives were set to keep this study on track

1. To find ways of prolonging the storage period of nyemba seeds

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2. To come up with a safe, affordable and sustainable method of storing nyemba seeds
3. To develop a natural fabric finish for jute fibres that will reduce damage of nyemba seeds by pests during storage.

SIGNIFICANCE OF STUDY

The study is significant to:

a. Communal farmers who grow legumes and other grains that are usually attacked by weevils and other pests who will be advised on how best to store their harvest.
b. Environmentalists by providing essential information on the use of natural biodegradable material in food packaging and storage.
c. The consumers of the stored nyemba seeds who will then have chemical and/or pest free products.
d. The Ministry of Environment and Tourism which will get information on environmental conservation.
e. The study will introduce to the body of knowledge, another fabric finish and food packaging that is not only indigenous but also organic and biodegradable.
f. Above all, the study will benefit the bulk of the nation since it subscribes to food security and addresses MDGs 1 and 2.

METHODOLOGY

The method was experimental, it was based on the approach by Barb (2009), it was not followed strictly but an experiment by Elsevier (2002) was adopted instead. This is where by plant extracts are diluted with water then the fabric is immersed in the water for several hours then left to dry before use. The method was further adapted by way of applying sodium hydroxide to the jute fabric prior to the application the finish so that the fabric would accept the finish more readily. The fabric was constructed into small bags into which nyemba seeds were stored.

Fresh Lantana Camara leaves were washed thoroughly under a running tap; 10 grammes were ground in a food processor to obtain a thick paste which was then diluted with 100ml of distilled water. The solution was then filtered through a muslin cloth to come up with a 10% aqueous extract solution which is mainly composed of essential oils. According to Adadire and Ajayi (1996) and Lore (2003), essential oils in Lantana Camara plant are caryophyllene, eucalyptol, a-humelene and germaerene-D, they contribute 47.74% of the plant extracts therefore help the fabric to maintain its softness.

Aim

To identify the effect of jute fabric to which Lantana Camara plant extracts have been applied as a fabric finish, on the weevil damage rate on legumes.

Materials

Untreated jute yarn was obtained from a local hardware and woven into fabric that was constructed into four bags (15cm x 35cm). Lantana Camara leaves used were collected from the trees in the forests near Mabika Village in Mberengwa District. Nyemba seeds were obtained from a communal farmer in the same district. Sodium hydroxide was obtained from PETUNA laboratories in Harare.

Method

The jute bags were soaked in water for 10 minutes washed in 1% soap-less detergent solution, thoroughly rinsed then further soaked in yet another 1% soap-less detergent solution at 80°C for a further one hour. They were then washed and rinsed thoroughly with distilled water, wrung and left to dry in an oven at 80°C for 24 hours. Three of the bags were then dipped in 5% sodium hydroxide solution (Na OH) at 30°C for 30 minutes (to improve the adherence of the plant extracts) after which they were rinsed with distilled water then hung to dry in the open. The fourth bag was left free of both NaOH and the fabric finish and was used as the control.

Fresh leaves of the Lantana Camara plant were washed thoroughly under a running tap, ground into a paste then solutions with two different concentrations (20% and 40%) were made with 100ml of water each then boiled for 10 minutes. To apply the finish, one of the jute bags that had been dipped in 5% NaOH was dipped in the 20% solution and the other one into the 40% solution for 30 minutes each. One was marked 20% and the other one 40% according to solution each had been dipped in for easier distinction and to avoid mixing up, then hung out to dry in the open. The third and fourth bags were labelled NaOH and Control respectively. The nyemba seeds used for the experiment were healthy and not infested, that is free from holes and any deformities and looked fresh. They were kept in a deep freezer for 14 days at -15°C to ensure that they were free from pests or any form of infection.

Each of the four jute bags was packed with 500 nyemba seeds, five of which were infested with weevils thus 1% infestation. The seeds were thoroughly mixed to distribute the infected ones. They were randomly stored on open selves at room temperature for twelve months. The number of damaged seeds was recorded for each bag on the 25th of every other month since it was the date on which the seeds were packed and infested. The Weevil Perforation Index (WPI) proposed by Roy et al. (2002) was interpreted as WPI>50 indicate a negative protection effect or an increase in infestation, WPI<50 indicate a positive effect or a decrease in infection. The following equation in figure 1 was used to calculate the WPI. The percentage seed damage was calculated as indicated in figure 2.

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

Figure 1. Equation used to calculate WPI

$$\%\ \text{seed damage} = \frac{(\text{Number of seeds damaged})\ 100}{(\text{Total number of seeds})\ 1}$$

Figure 2. Fomulae used to calculate percentage seed damage

RESULTS

Control

With the control experiment, after 60 days, the seed damage rate had risen from 1% to 3.2% as shown in table 1. It continued rising up to 360 days when 15.4% seed damage was recorded, the number of weevils had multiplied several times and they were continuing the with damage and multiplication. The WPI at360 days had risen to 86.5. Moths and white worms were also found inside the bag, they were all living.

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Table 1. Percentage seed damage as recorded every 60 days

Days	*60*		*120*		*180*		*240*		*300*		*360*		*WPI*
Treatment	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	
Control	16	3.2	27	5.4	39	7.8	54	10.8	63	12.6	77	15.4	86.5
5% NaOH	15	3.0	25	5.0	33	6.6	48	9.6	57	11.4	69	13.8	77.5
5% NaOH+20% LC Extract	12	2.4	15	3.0	24	4.4	24	4.4	24	4.4	24	4.4	7.2
5% NaOH+40% LC Extract	10	2.0	12	2.4	12	2.4	12	2.4	12	2.4	12	2.4	3.9

Jute bag with 5% NaOH

This bag had no fabric finish applied to it, its purpose was to establish whether the seed damage rate was influenced by NaOH or the LC fabric finish. At the end of 60 days, the percentage seed damage had risen from 1% to 3% and continued rising up to 13.8% at the end of 360 days. The number of weevils had risen and they were continuing with the damage since the weevils were seen actively gnawing the seeds. The WPI by the end of the 360 days was at 77.5, that is, slightly less than that of the control. Besides weevils, living moths and white worms were found inside the bag.

Jute bag to which 5% NaOH+ 20% LC fabric finish was applied

This bag had the seed damage raised from 1% to 2.4% by the end of 60 days. The rate of damage continued rising gradually until at the end of 180 days when the percentage damage was recorded as 4.4%. No further damage was recorded thereafter. At the end of 360 days, no weevil was found alive inside the bag, the seed damage rate stood at 4.4% (24 seeds) and the WPI was 7.2 at 360 days thus far below the control and that of seeds in bag with no finish applied to it. No other pests were found inside the bag.

Jute bag to which 5% NaOH+ 40% LC fabric finish was applied

In this bag, the seed damage doubled within 60 days. The reading at the end of 120 days showed that the seed damage raised by only 0.4 % after the 60 day count. No further damage was observed after the record at 120 days, all weevils inside the bag were found dead at this point. The WPI at the end of 360 days was calculated to be 3.9, that is, it was even lesser than that of fabric to which 20% LC fabric finish was applied. No other pests were found inside the bag.

DISCUSSION

The cumulative rate of seed damage presented in table 1 shows that in jute bags to which LC fabric finish was applied was relatively low and eventually came to a standstill. The 40% concentration had a maximum seed damage of 2.4% which stopped before the end of 120 days while the 20% concentration had it at 4.4% which discontinued before the end of 180 days. This proves that the L C fabric finish improved the performance of the jute fabric by probably suffocating the weevils and barring those from outside from entering the jute bags, thus protecting the seeds inside as has been pointed out by Ivbijaro (1984). This is evidenced by the non existence of living weevils and discontinuation of seed damage in jute bags with 40% and 20% fabric finish at 180 days and 120 days respectively.

Basing on the findings of the study, the seed damage was highest in the control experiment, followed by jute bag with 5% NaOH only, then the one with 20% fabric finish and least in jute bag with 40% fabric finish. This shows that the L C fabric finish was able to protect the legumes from damage by weevils, and, the higher the concentration of the fabric finish, the lower the rate of damage and the earlier the weevils die, thus stopping further damage to the seeds. The natural fabric finish can guarantee maximum seed protection especially with the 40% L C fabric finish concentration. This does not apply to the small bags only but also to the usual 50kg and 90kg bags the farmers commonly use for storing seeds and grains. This definitely reduces food harvest losses and increases the farmers' outcome as propounded by Fellows 2002. The fact that no other pests were found inside the bags with LC fabric finish shows that the finish protects the seeds from not just weevils but other pests as well.

Storage bags made from jute fabric to which L C fabric finish has been applied are both user and environmental friendly. They are user friendly in that consumers will consume the seeds with their natural taste and free from weevils, thus reducing the risks of pest induced allergies as cited by Champ and Dyte (1976). They are environmental friendly in that the worn-out bags can be disposed without causing environmental degradation since the jute fabric used and is biodegradable and the finish applied is organic. Jute fibres are also renewable as indicated by Azam, et al (2011). The affordability of both the fabric and the natural finish as pointed out by Pan, et al (2004) makes the mode of storage readily accessible by most of the famers.

The results also reveal that the WPI for jute bags with LC fabric finish had their WPI much less than 50 ($3.9 < 50$ for 40% fabric finish concentration and $7.2 < 50$ for 20% fabric finish concentration) indicating positive proctectant effects. The WPI for the control experiment and for the jute bag with NaOH only was greater than 50 ($86.5 > 50$ and $77.5 > 50$ respectively) implying that there was a negative protectant effect. In the bag with NaOH, there could have been very little disturbance of the weevil damage yet there were no disturbances in the control, hence the difference. The environment was conducive for weevil perforation in the later bags; the rapid increase in seed damage may be as a result of each weevil concentrating on a separate seed while the reduction may be due to more than one weevil concentrating on the same seed at the same or different times.

CONCLUSION

After analysing the results, it was concluded that there are several methods of prolonging the storage of legumes. The natural fabric finish developed from Lantana Camara extracts improved the performance of jute fabric by making it protect nyemba seeds from damage by weevils and other pests for a period up to one year. The method was found to yield the best results for the famers in protecting the seeds because it is safe, affordable, easily accessible and sustainable. It protects the seeds without interfering with their taste and flavour, does not bring in any side effects and does not degrade the environment.

RECOMMENDATIONS

Having gone through this study and drawn conclusions, the following recommendations were made:

1. All farmers who grow nyemba seeds and other seed legumes consider using jute bags to which LC fabric finish has been applied so that their harvest can be stored for longer periods without damage by weevils and other pests
2. The Ministry of Agriculture, in conjunction with the Textile Industry through their research stations, try the method with other seeds and grains used as food.

3. The Textile Industry commercialises the process so that it can be utilised at a larger scale by commercial famers since it significantly contributes food security.
4. Further research focuses on trying the fabric finish on other fabrics used in food packaging

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