

## PAPER 88 – Effects of Surface Linings and Thickness of Lining on the Microbial Load of Stored Onion Bulbs (*Allium Cepa L.*)

O.V. Adeyinka-Ajiboye<sup>1</sup>, M.O. Sunmonu<sup>2</sup>, M. M. Odewole<sup>2</sup>

<sup>1</sup>Department of Agricultural & Biosystems Engineering, University of Ilorin, PMB 1515, Ilorin 240003, Nigeria

<sup>2</sup>Department of Food Engineering, University of Ilorin, PMB 1515, Ilorin 240003, Nigeria

Email: ajiboye.oa @unilorin.edu.ng

### ABSTRACT

The study was done to investigate effects of surface linings (jute, foam and polypropylene) and thicknesses (single 2.1, 8.91 and 0.44mm, double 4.20, 17.82, 0.88 mm and triple 6.30, 26.73, and 1.32 mm) of lining on the microbial load of onions bulbs stored for 6 months in an instrumented wooden structure. Kano-Red variety of onions was used for the experiment. ANOVA was used to study the effects of types and thickness of lining layers on onion bulbs in storage. During storage, both the treated and the control onion bulbs showed a general rise in microbial load in storage. The control displayed a starting value of  $10^3$  CFU/g and a final value of  $80.5 \times 10^2$  CFU/g. Polypropylene double had the lowest value of microbial load ( $11.5-54.75 \times 10^2$  CFU/g), while Jute single and Jute triple had equal values in the range of (10.75-71.75). Jute double had the highest initial and final values of (14.5 CFU/g -77.25 CFU/g). Conclusively, it can be said that despite the general increase in microbial load between the control and the treated, treated samples still had lower microbial load.

**KEYWORDS:** onion bulbs, storage condition, surface lining, lining thickness and microbial load

### 1. INTRODUCTION

Onion (*Allium cepa L.*) is a vegetable bulb crop that is popular all over the world and is known to most cultures. Its production is only second to that of tomatoes (FAO, 2012). Because of their particular flavour, onions are recognized by people as one of the vegetable crops with a wide range of uses (Emmanuel *et al.*, 2022). The health profits of onion are largely credited to its various bioactive components, such as organosulfur compounds, phenolic compounds, polysaccharides, and saponins (Marrelli *et al.*, 2019; Teshika *et al.*, 2019). The more potent onion varieties appear to provide the largest concentration of compounds that support health. According to the National Cancer Institute, onions are reported to contain antioxidants that may prevent cancer and lower cholesterol (Indu, 2017). Onions can be harvested in dry conditions, but they are more susceptible to disease following harvest after a rain or when the humidity is high.

Onions have long been grown for both food and profit across the savannas of West Africa (Kassam, 2011). Nigeria, a nation in sub-Saharan Africa, ranks among the top countries in the world for onion production (Jolayemi *et al.*, 2018). The majority of the onion production in Northern Nigeria is done in the states of Kaduna, Kano, Jigawa, Katsina, Sokoto, Kebbi, Plateau, and Bauchi, specifically in the dry tropical zone (Anyanwu, 2003). Onion bulbs are so fragile and frequently suffer injury during preservation. Different types of onion bulbs require different storage temperatures, such as 0–5 °C for some and 25–30 °C for others, with an average relative humidity of 65% (Ayalew, 2018). Postharvest onion bulb losses from sprouting and rotting range from 46 to 56% depending on the storage environment and system used (Ayalew, 2018). Controlled environments can be utilized to store onions for a long time. Despite being more expensive than traditional storage, this method boosts crop value by increasing the product's window of opportunity for sale (Ayalew, 2018). During storage, onions are susceptible to rotting, sprouting, and physiological weight loss.

The strong demand for and popularity of this type are due to its superior shelf-life. It is well-established that proper aeration reduces storage losses in onion. Incorporating forced air in the storage will provide adequate ventilation (aeration) which subsequently reduces rotting and sprouting of the stored onions. Unexpectedly, over one-third of the food produced for human consumption worldwide is wasted or lost each year (Delgado *et al.*, 2017). This is significant since it shows that food loss and waste in developing nations costs over \$310 billion USD (FAO, 2011). Sadly, onions are one of the major crops affected. The (*Allium cepa L.*) plant's shelf life is essential to the onion industry.

The main objective of this research was to study the effects of lining layers of an onion storage structure on the shelf life and nutritional compositions of onion bulbs. The specific objectives of this study were to: design and

construct a forced air ventilated storage for onions as a test rig and investigate the effects of surface linings and thickness of surface lining on the shelf life and microbial load of stored onions.

## 2. MATERIALS AND METHODS

### Experimental Location

The study was conducted at the Agricultural Storage Room of the Department of Agricultural and Biosystems Engineering (longitude 4°35' E and latitude 8°30' N), University of Ilorin, Ilorin, Kwara State between May 26 and November 26, 2022 (24 weeks). The agricultural warehouse has a storage capacity of 8.15 x 7.02 m<sup>2</sup>. Jute, polypropylene and foam in different thicknesses were used as lining materials to line the boxes within the storage structure where the onion bulbs to be stored were kept. Fumigation of the outside surrounding was done to treat termites, pests and the likes from invading the store.

The Onion bulbs (Kano-Red) variety that was used for the storage experiment was purchased from National Horticultural Research Institute (NIHORT), Kano State, Nigeria. The onion bulbs were cleaned, sorted and graded according to their sizes hence, healthy, firm, matured and whole bulbs were used for the experiment.

The major piece of equipment for this experiment is the high-density fibreboard that was utilized to construct the storage structure containing the three boxes lined with materials. The equipment and supplies used for this experiment include an electronic platform weighing scale (TCS Series), a Model CL 201 scale (220g x 0.1g), a digital vernier calliper (0-150mm), a galaxy sensors thermometer (v1.8.10), a hygrometer (0-100% Tasjkovski Labs), suction fans, renewable energy source wattage (260 W) and onion bulbs (kano- red).

### Design Calculations

#### Volume of Storage Structure

The volume of the structure was calculated using the formula below:

$$\text{Volume of the upper section (internal)} = \quad \quad \quad (\text{m}^3) \quad \quad \quad (1)$$

$$\text{Volume of bottom section (internal)} = \quad \quad \quad (\text{m}^3) \quad \quad \quad (2)$$

$$\text{Total volume (internal)} = \text{Volume of the upper section (internal)} + \text{Volume of bottom section (internal)} (\text{m}^3) \quad (3)$$

$$\text{Volume of the storage box (internal)} = (\text{m}^3) \quad \quad \quad (4)$$

Where,

a = internal long base edge of upper section, 0.945m , b = internal short base edge of upper section, 0.225 m

= internal height of upper section, 0.162m , = internal Length of upper section, 0.315m

= internal length of bottom section, 0.945m, = internal breadth of bottom section, 0.315m

= internal height of bottom section, 0.664m, = internal length of storage box, 0.282m

= internal breadth of storage box, 0.273m, = internal height of storage box, 0.127m

i. Volume of the upper section (internal) =

=

= =

= m<sup>3</sup>

ii. Volume of bottom section (internal) =

=  
= m<sup>3</sup>

iii. Total volume (internal) = Volume of the upper section (internal) + Volume of bottom section (internal)

=

= m<sup>3</sup>

iv. Volume of the storage box (internal) =

=  
= m<sup>3</sup>

#### Fan Selection

According to Bartok (2013), fan selection in a storage structure is calculated using Equation

$$(5)$$

Where; F<sub>c</sub> is the fan capacity; and A is the floor area of the storage structure.

Since is calculated to be

Therefore,

However, a factor of safety is highly essential in the design of components. For the fan, a factor of safety of 10% was selected and the actual and required fan capacities are expressed in Equations 3.4 and 3.5, respectively

(6)

(7)

Where  $F_C$  is the fan capacity;  $F_A$  and  $F_F$ , are the actual fan capacity and the required fan capacity, respectively.

Substituting into Equation 3.4 and 3.5,

#### Experimental Procedure and Set Up

The storage structure that housed the onion bulbs is hexagonally-shaped with a height of 0.837 m and external base width is 0.975 mm. The storage box that is enclosed in the main structure is a rectangular-shaped box with dimensions of 0.282 x 0.273 x 0.127 m lined with jute, foam and polypropylene of single thicknesses 2.1, 8.91 and 0.44 mm, double thicknesses 4.20, 17.82, 0.88 mm and triple thicknesses 6.30, 26.73, and 1.32 mm per storage box respectively. A brushless suction fan DC Scirocco Ace Model: 109BF 12HA2, DC 12V = 0.6A was installed at the top of the storage structure to suck out the heat within the system. The surface speed of the fan when working on solar and direct electricity power was 134 and 169 r.p.m respectively. Five kilogrammes of forty onion bulbs were stored in each storage box of twenty-seven boxes and one control, which equals a total of one thousand, one hundred and twenty onion bulbs (1,120). Total weight of onion stored was one hundred and forty kilogrammes (140 kg). Powered by direct connection to electricity supply also to a solar with total wattage of 260 w. Each of the nine (9) high-density fibreboard constructions had three boxes, each lined with foam, jute, and polypropylene, and each contained a known quantity of clean onion bulbs weighing five kilogrammes (kg), which were stored inside the structure. To act as the experiment's control, five kilograms (5 kg) of onion bulbs was spread out on the floor.

The ambient temperature and relative humidity of the space where the storage structures were kept was monitored during the storage time.

#### Data Collection

Each month, samples of onion bulbs were taken for microbial analysis. Fungi count was carried out using potato dextrose agar. The results obtained for each count was recorded as colony forming unit per ml (cfu/ml) of sample as shown in equation (8). This involves the same procedures as bacterial count; however, Potato Dextrose Agar was used. After allowing the agar in the petri-dish to solidify, the plates were incubated at room temperature at 27 °C for 48 hours. After the incubation period, the plates were counted and recorded.

Fungi count (cfu/ml) = (8)

#### Storage Procedure

The techniques utilized for storage included carefully labeling the storage structures according to type of lining material and thickness, assembling and storing the products in storage structures and at ambient condition. The structures were inspected for any undesirable openings that could allow pests like rodents and insects inside. Each storage structure in this investigation has two sets of 3" elevated castor legs that extend above the floor.

#### Statistical Analysis

Microsoft Excel 2010 was used to analyze the experimental data for analysis of variance (ANOVA). Model equations were generated with General Factorial Experiment module of the Design Expert Version 6.0.6. Furthermore, there was no meaningful comparison between the results because the difference in the results was so minimal. All of the model equations' sufficiency and validity were examined using numerical and graphical methods.

### 3. RESULTS AND DISCUSSION

The results presented in Figure 1 showed that both the treated and the control onion bulbs exhibited a general rise in microbial load in storage. The control displayed a starting value of  $10^3$  CFU/g and a final value of  $80.5 \times 10^2$  CFU/g. Polypropylene double had the lowest value of microbial load (11.5–54.75  $10^2$  CFU/g), while Jute single and Jute triple had equal values in the range of (10.75–71.75). Jute double had the highest initial and final values of (14.5 CFU/g -77.25 CFU/g).

While from beginning to the end, foam triple had the value increase range of (10.25–71.00 CFU/g). Foam single had the initial fungi value range of (10.25–68.5), followed by foam double (9.75–66.75 CFU/g). Polypropylene triple revealed (11.75–69.5 CFU/g) and Polypropylene single (11.25–66.5 CFU/g). There is a concern to the public's health since onion bulbs contain large quantities of this fungus (Onuorah and Obika 2015). Commonly, growth of bacteria and fungi is confined to water activity ( $a_w$ ) levels above 0.90 (Lund *et al.*, 2000). Unlike bacteria that cannot grow below 0.85  $a_w$ , fungi are more tolerant to reduced  $a_w$  and can grow even below 0.80 (Lund *et al.*, 2000; Sagar and Suresh, 2010). While, the lowest  $a_w$  at which growth of bacteria has been reported was 0.75, fungal growth has been recorded at  $a_w$  levels as low as 0.61 (Lund *et al.*, 2000). Leistner (1992) reported that moisture content and water activity ( $a_w$ ) of artificially dried fruits and vegetables range from 15 to 50% and 0.60 to 0.89, respectively. These conditions can only cause dormancy in bacteria and fungi until a favourable environment is attained (Prescott *et al.*, 2001; Sagar and Suresh, 2010).

Microbial counts and pathogens higher than international stipulated limits ( $10^3$  CFUg<sup>-1</sup> for fungi and  $10^1$  CFUg<sup>-1</sup> for bacteria) in both commercially and conventionally produced fresh and dried fruits and vegetables have been reported (BarkaiGolan and Paster, 2011; Johannessen *et al.*, 2002; Mensah *et al.*, 2002; Witthuhn *et al.*, 2005). This assertion justifies the increase in total fungi count during the course of this study. The absence of the infrastructure required for the successful application of these technologies is a significant additional issue. Onion storage structures may be designed to maximize natural ventilation. Post-harvest management for agricultural products aims to achieve this by minimizing agricultural product loss or waste continues to be the main goal of post-harvest management systems. According to various studies that reported on onion postharvest technologies, using both conventional and innovative methods can effectively help to enhance the shelf life of onion produce.

The presence of these fungi in the onion bulbs is attributable to the environmental conditions, state of handling and processing, state of storage facility of the onions, the fungal load of the handlers and the quality of the onion bulbs. These fungi have been known to cause diseases of humans and animals. They may come from the air, water, soil and even the handlers. They are the sources of highly potent mycotoxins which are hazardous to health. The presence of these fungi in significant numbers in onion bulbs is therefore a public health risk. Fungal spoilage of onions also has a negative economic effect on the economy of the onion bulbs farmers in particular and the economy of the country in general. The control of the fungal spoilage of onion bulbs is therefore inevitable. Proper storage conditions, careful harvesting, protection of the bulbs from sunburn, provision of adequate ventilation and regular examination during storage will minimize the entry and proliferation of these organisms in the onion bulbs, thereby reducing the incidence of diseases they cause and also improve the economy by reducing wastes resulting from spoilages.

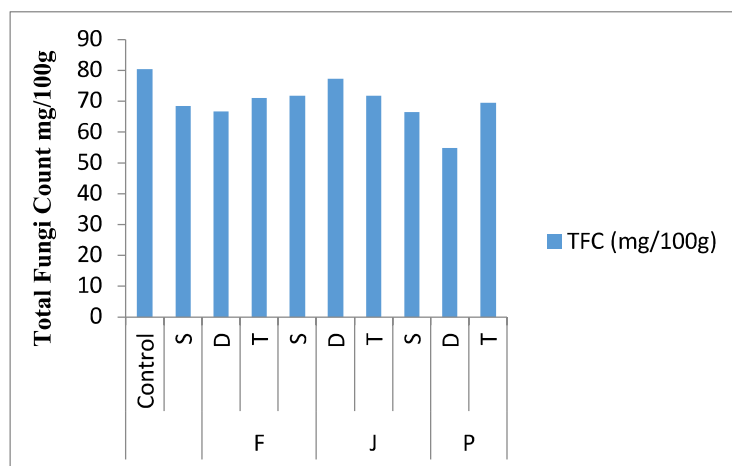


Figure 1: Graph of Total Fungi Count versus Lining Thickness

#### 4. CONCLUSION

In conclusion, it can be said in terms of type of lining material and material thickness that onion bulbs stored were affected by an increase in total fungi count in this investigation which needs to be properly looked into and completely minimized in further investigations. The control exhibited the highest value  $80.5 \times 10^2$  CFU/g of total fungi count in storage which means that for excellent postharvest management, keeping onion bulbs in the storage structure is safer for human health than just spreading on the floor. Other vegetable types could be researched on using the same storage structure and experiment done to check the effects of types of lining and lining layers on the shelf life and nutritional composition of the selected agricultural crop.

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