Effect of drying method and storage conditions on quality and incidence of aflatoxins in dried chillies (*Capsicum frutescens*) in Zimbabwe

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Abstract

Zimbabwean farmers have to continue producing a good quality product that is free from aflatoxin contamination or is below the maximum acceptable levels of aflatoxin contamination in order to export chilli. Four chilli varieties, African bird's eye, Baby bird's eye, Serenade and Bishops crown are available on the local market. Chilli destined for the export market was free from aflatoxin contamination. Chilli on the local market contained AFB1 and AFB2 both at an average of 6ppb. Drying chilli in Marondera using 3 different methods gave a significant difference ($P<0.05$) in total aflatoxin levels and days needed for drying. Different packaging treatments used did not have a significant effect ($P>0.05$) on any of the quality parameters measured or on total aflatoxin levels. The combined effect of drying method and packaging material did not have a significant effect on total aflatoxins, ascorbic acid content, pH and moisture content of the dried chilli.

Keywords: aflatoxin, African Birds eye, chilli, dryer, packaging, *Capsicum frutescens*

1. INTRODUCTION

The chilli (*Capsicum frutescens*) is a plant native to Mexico but is now being grown in many countries around the world including Zimbabwe. Chilli is used as a spice and due to its pharmacological properties it is also used in medicine (8). Worldwide red chillies are becoming popular as they are used extensively in blended spices (6). Chilli can also be used in the control of pests and diseases and in integrated pest control (IPM) programmes. Chilli is also a good source of vitamin A, C and E and it is also known to improve the digestive system.

In Zimbabwe, interest in the production of the crop is on the rise as smallholder farmers have been assisted to enter the lucrative export market of Tabasco® chillies by the Better Agriculture Company (BAC). In Zimbabwe this company is working with farmers in and around Masvingo and Chiredzi. The Tabasco® chilli project aims to improve the livelihoods of rural farming communities in Africa through sustainable business development (9). Zimbabwean farmers are now producing Tabasco® chillies and African bird's eye chilli for both the local and export market.

Currently, Zimbabwe is ranked number 94 in world production of chilli, and the tonnage produced has increased from 100 tonnes in 1990 to 1994 tonnes in 2011 (4). Other organisations involved in promoting chilli production in Zimbabwe include the International Rescue Committee (IRC), Agritex and the Swedish International Development Agency (SIDA). The Zimbabwe Agricultural Income and Employment Development (Zim-AIED) program is also assisting farmers to produce African bird's eye chilli, Tabasco® chillies and cherry peppers for export. During the period from January to March 2013, Zim-AIED assisted farmers to export 176 tonnes and 4.6 tonnes of Tabasco® chilli and African bird's' eye chilli through BAC. This produce was exported to South Africa and the European Union for further processing (5).

The EU is currently lobbying for a reduction in the maximum acceptable levels of ochratoxin A (OTA) in chillies. OTA is a mycotoxin produced by *Aspergillus ochraceus, Aspergillus carbonarius* and *Penicillium verrucosum*. The OTA limits might be reduced to 15µg/kg instead of the current 30µg/kg. This will be effective from 1 January 2015 if the legislation passes (2). The passing of this legislation will make it very difficult for chilli producers in tropical areas to export to the EU as their climate promotes both aflatoxin and ochratoxin development. Tropical regions are characterised by high humidity and high temperatures, conditions that favour fungal growth and mycotoxin production.

Zimbabwean chilli farmers have been availed the opportunity to enter the lucrative export market and in order to keep their market share they need to continue producing a high quality product. There is also potential to enter the European market if the required standards are met. One of the most important quality attributes for chilli is the absence of aflatoxin contamination. In the European Union, for example, the maximum acceptable level of AFB_1 and total aflatoxins in red chilli is 5 and 10µg/kg respectively (3).

Zimbabwean farmers therefore need to be provided with information on aflatoxin management in chilli and chilli products. Information needs to be provided on the ideal drying conditions and packaging materials that can be used in order to prevent aflatoxin contamination or to at least keep it at levels below the maximum acceptable threshold levels.

2. OBJECTIVES

The objectives of the study were:

a. To determine the effect of drying method on quality and incidence of aflatoxins on chillies

b. To determine the effect of packaging material on quality and incidence of aflatoxins in chillies during storage

3. METHODOLOGY

The experiment was conducted at the Horticultural Research Institute (HRI) in Marondera. HRI is located at an altitude of 1630m a.s.l, latitude 18^{o}11’ S and longitude 31^{o}28’ E. The experiment was conducted from the end of March 2014 to the end of June 2014.

The chilli used in this experiment was dried using sun drying, solar cabinet drying or oven drying. The aflatoxin levels of the chilli and the moisture content were determined before the chilli was put into the different packaging treatments.

3.1 Drying Methods Used

The sun drying treatment was carried out on a slanting aluminium rooftop. The chilli was spread out in a single layer and the drying was carried out from 8am to 4:30pm daily until the chilli was dry. In the evening the chilli was placed in plastic crates and stored indoors.

The oven drying treatment was done using a Genlab OV/75/SF oven. The Genlab oven uses circulating hot air to dry the produce. The oven has three wire rack shelves and the chilli was spread out in a single layer on each of these three shelves. The chilli was dried at a temperature of 65^{o}C for 12 hours, with the oven door left partially open in order to prevent cooking of the chilli.

The solar cabinet dried chilli was dried using a three shelf cabinet solar dryer model with a solar collector and a chimney. Drying was carried out from 8am to 4:30pm daily until the chilli was dry. The chilli was removed from the drier at sunset, placed in plastic crates and stored indoors overnight.

In all three treatments the chilli was dried until it obtained a crisp texture and made a rattling sound when shaken. The chilli trays were rotated regularly inside the dryer in order to ensure that the chilli dried evenly. The moisture content of the dried product was recorded. Moisture content of the chilli was measured using a moisture analyser (MOC63u, Shimadzu Moisture Analyser). The moisture analyser was set to measure moisture at a temperature of 120^{o}C.

During the drying period the samples were visually checked daily for mould development. The other parameters monitored included the daily temperature readings, the number of days taken to dry each sample and the weight of the sample after the drying period. Colour changes were monitored using visual assessment.

The dried chilli sample from each drying method was then divided into four equal portions by weight, and these were randomly assigned to each packaging material. The four packaging treatments were hessian bags, plastic lined hessian bags, khaki paper packaging and reed baskets. The control was the hessian bags.The hessian bags used measured 42cm in length and 35cm in diameter. The plastic lined hessian bags had a plastic layer sewn in on the inside of the bag. The khaki bags measured 33cm in length and 23cm in width. The reed baskets were 26cm in diameter and 12.5cm deep.

The samples were stored in the laboratory at room temperature. Daily recordings of temperature and humidity were taken in the laboratory. The readings were taken using a wet and dry bulb thermometer. Samples were taken at monthly intervals for a period of three months and were checked for mould development and for aflatoxin contamination.

Moisture content, pH and ascorbic acid content were also measured as quality parameters. Moisture content of the chilli was measured using a moisture analyser (MOC63u, Shimadzu Moisture Analyser). Moisture content was measured at 120^{o}C. pH was measured using a Jenway pH meter 3310. Ascorbic acid content was measured using the iodine titration method.

This experiment was set up as a 3x4 factorial and the data obtained was analysed using the statistical package GenStat discovery edition 3. The data was analysed using a two way ANOVA with randomised blocks.

4. RESULTS

The average minimum temperature recorded during the three month storage period was 15.8^{o}C while the average maximum temperature was 20.9^{o}C. The average relative humidity was 58%. The results obtained on the parameters measured are summarised in Table 1.

4.1 Ascorbic acid content

There was a significant effect ($P<0.001$) of drying method on ascorbic acid content of the dried chillies (Table 1). The highest ascorbic acid content was recorded with chillies dried using the solar cabinet dryer but it did not significantly differ when the chillies were sun dried. A significantly lower ascorbic acid content in the dried chillies was recorded when the chillies were oven dried than when they were dried directly in the sun or in the solar cabinet dryer. Packaging did not cause a significant effect ($P>0.05$) in ascorbic acid concentration in the dried chillies. No significant interaction ($P>0.05$) was observed between drying method and packaging material on the ascorbic acid concentration of the chilli (Table 1).

4.2 Moisture Content

The different drying methods produced a significant effect ($P<0.001$) on the moisture content of the dried chillies. The highest moisture content was recorded when the chillies were dried directly in the sun but it did not significantly differ to when the chillies were dried in the solar cabinet dryer. The moisture content recorded when the chillies were oven dried was significantly lower than when the chillies were dried directly under the sun or in the solar cabinet dryer. Packaging did not cause a significant effect (P>0.05) in moisture content of the dried chillies. No significant interaction was observed between drying method and packaging material on the moisture content of the chilli (Table 1).

4.3pH

There was a significant effect (P<0.001) of drying method on the pH of the dried chillies. Sun dried chillies recorded the highest pH but it did not significantly differ when the chillies were dried in the solar cabinet dryer (Table 1). A significantly lower pH was recorded when the chillies were oven dried than when they were dried directly under the sun or in the solar cabinet dryer. Packaging did not cause a significant interaction (P>0.05) in pH of the dried chillies. No significant interaction (P>0.05) was observed between drying method and packaging material on the pH of the dried chillies (Table 1).

4.4 Aflatoxins

The different drying methods produced a significant effect (P<0.001) in the total aflatoxin levels of the dried chillies after three months in storage. The highest aflatoxin level was recorded in the chillies that were dried using the solar cabinet dryer and these were significantly different to the total aflatoxin levels recorded when the chillies were dried directly under the sun (Table 1). No aflatoxins were recorded in the oven dried chillies. Packaging did not cause a significant interaction (P>0.05) in total aflatoxin levels of the dried chillies. No significant interaction (P>0.05) was observed between drying method and packaging material on the total aflatoxin levels of the chillies (Table 1).

4.5 Effect of time in storage

There was no interaction observed between time in storage and packaging material on moisture content, pH and ascorbic acid content. However as the time in storage increased up to 3 months there were significant differences observed in the moisture content, pH and ascorbic acid content of the chilli. Interaction between time in storage and drying method used produced a significant difference (P <0.001) for moisture content and for ascorbic acid content (P<0.007). A similar interaction was observed for pH

Table 1: Effect of drying method and packaging material on quality parameters and aflatoxin levels in chilli

Treatment	Ascorbic acid content mg/100g	Moisture Content (%)	pH	Aflatoxin levels (ppb)
Drying Method				
Sun drying	22a	7.977a	5.112a	5a
Oven drying	13.58b	7.003b	4.878b	0b
Solar cabinet drying	24.75a	7.765a	5.092a	7.33c
p – value	<0.001	<0.001	<0.001	<0.001
l.s.d	3.169	0.3586	0.1030	1.131
%cv	9.8	8.5	2.5	25.7
Packaging Material				
Reed Basket	19.11	7.761	5.094	4.22
Khaki Packaging	18.72	7.729	4.989	4.11
Hessian bag	20.39	7.538	4.988	4
Plastic lined hessian bag	22.22	7.299	5.037	4.11
p – value	0.218	0.109	0.230	0.988
l.s.d	3.659	0.4141	0.1189	1.306
%cv	9.8	8.5	2.5	25.7
Drying method x packaging material interaction				
p – value	0.221	0.830	0.415	0.963
l.s.d	ns	ns	ns	ns
%cv	18.6	5.6	2.4	32.5

As time in storage increased the moisture content increased up to the second month in storage. After three months in storage the moisture content had gone down. A similar trend was observed for all the packaging treatments utilised. These trends are shown in Figure 1 and Figure 2

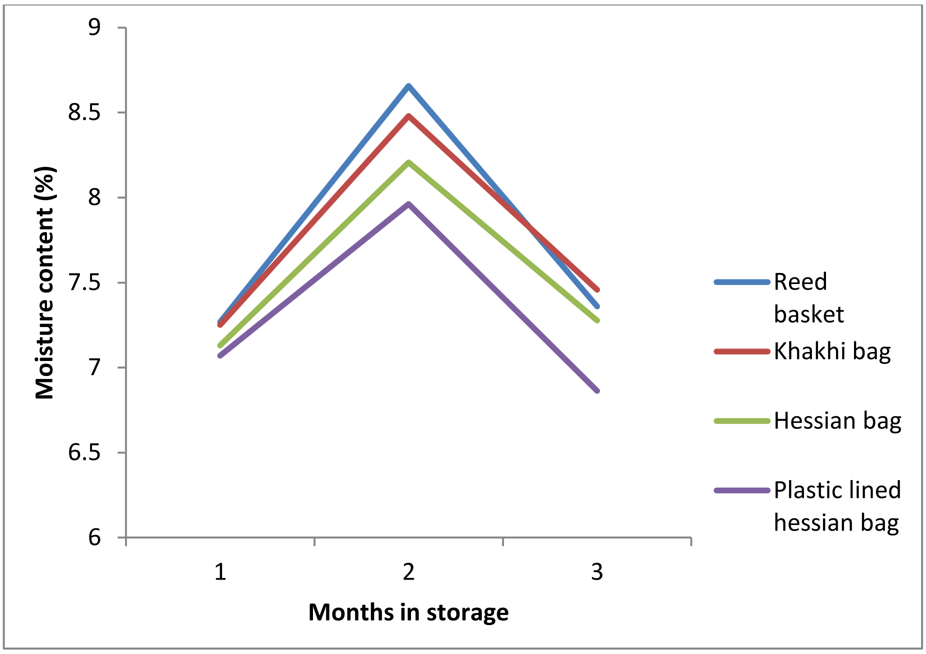

Figure 1: Change of moisture content with increasing time in storage

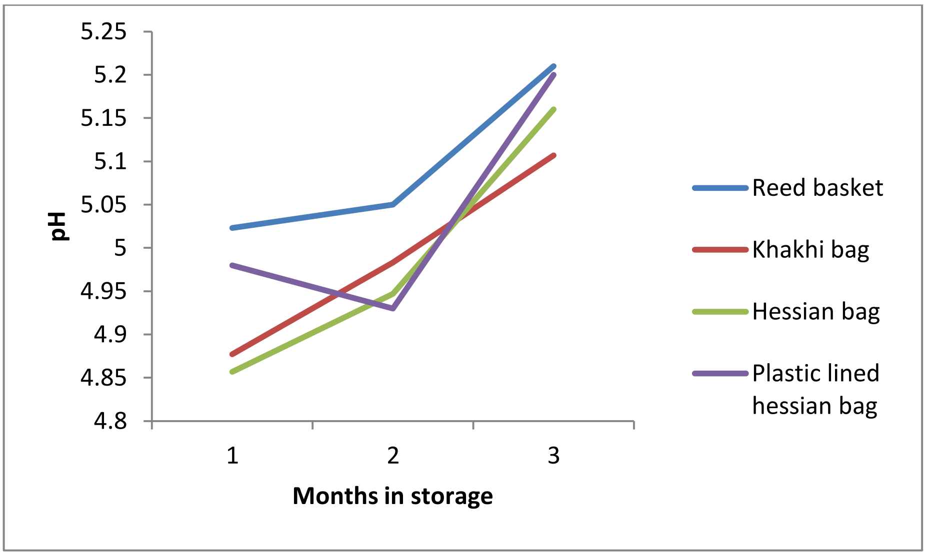

Figure 2: Change of pH with increasing time in storage

No signs of insect damage were observed on the dried chilli in all the four packaging treatments.

5. Discussion

No interaction between drying method and packaging material was found for all the quality parameters analysed. This means that under the storage conditions experienced during the three month period the different packaging materials did not affect the quality attributes. The quality attributes were determined by the drying method used and all the packaging materials managed to maintain those attributes in a similar manner.

Time in storage did show significant differences in moisture content and ascorbic acid content. Research done in India showed that biochemical constituents of cold stored chilli such as ascorbic acid decrease gradually with increasing time in storage (7). This agrees with the results obtained in this study which also showed a gradual decrease in ascorbic acid content.

The moisture content increased slightly in the first month in storage and then decreased. This low moisture content could be the reason why the aflatoxin levels did not increase. Foods with low moisture content generally have a low water activity (aw) which is a measure of the amount of free water in a food that can support the growth of moulds and bacteria. Water content and water activity have a nonlinear relationship that shows that at a given temperature and pressure as water activity increases the water content also increases (10). Research done on the Ethiopian red chilli variety 'Marekofana', on moisture sorption isotherms revealed the relationship between moisture content and water activity (10).

Using that data it can be suggested that at the low moisture content that the chilli was dried to (4.4% for oven dried chilli), the water activity was low enough to prevent the colonisation of the chilli by the fungi. The solar dried (5% moisture content) and the sun dried chilli (4.3% moisture content) were contaminated during drying but the water activity was then reduced to a point where it inhibited the further development of the *Aspergillus* flavus. The different packaging materials maintained the moisture content at levels that were low enough to inhibit aflatoxin production.

The aflatoxin levels did not change significantly over the three month storage period. This could be explained by the temperature and humidity conditions under which the chilli was stored. The average minimum temperature recorded was 15.8^{o}C while the average maximum temperature was 20.9^{o}C. The average relative humidity was 58%. Aflatoxin contamination is favoured by warm humid conditions. It has been proven that aflatoxin causing fungi do not favour cool climates (1), and this could be why the dried chilli that was stored when it was aflatoxin free did not get contaminated during storage.

6. Conclusion

It can therefore be concluded that under the cool climatic conditions experienced in

Marondera, African bird's eye chilli should be oven dried in order to avoid aflatoxin contamination. When stored under cool, dry conditions dried chilli can be safely stored in reed baskets, plastic lined hessian bags, hessian bags or khaki packaging for up to three months without becoming contaminated with aflatoxins

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