Efficacy of Plasma Technology in Eliminating Fungi and Aflatoxins in Maize in Makueni and Baringo Counties, Kenya

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Abstract

Maize (Zea mays var. indentata L.) is the most important food security crop in Kenya and plays an important role in human nutrition. Over the years, there has been increased concern over the rising cases of aflatoxin poisoning in Kenya due to contaminated maize especially in Eastern and North Rift parts of the country. This has led to huge losses not only in the country's breadbasket areas but also in the national grain reserves. Aflatoxins are fungal toxic metabolites that naturally contaminate food and feed. Exposure to aflatoxins is associated with various cancers, suppressed immunity, retarded growth, mutations, and aggravation of other existing conditions such as HIV among others. Plasma technology presents a possible solution. Plasma is electrically energized matter in gaseous form that is generated at different conditions of temperature, pressure and ionization power. Low temperature plasma is an emerging technology that is finding space in the food industry particularly in decontamination processes. Use of plasma at low temperature makes the decontamination process practical, inexpensive and suitable for products where high temperatures are not desired. The main objective of this study was to determine the efficacy of plasma technology in destroying fungi and aflatoxins in maize in Makueni and Baringo counties in Kenya. The specific objectives were: to determine the influence of knowledge, attitude and practices of farmers on aflatoxin contamination of maize in Makueni and Baringo counties in Kenya, to determine the influence of postharvest practices and storage conditions on aflatoxin contamination in maize in the two counties, to isolate and characterize the fungi responsible for contamination in both counties and finally to determine the efficacy of plasma technology in destroying fungi and aflatoxin in maize. A convergent mixed method study design that combined quantitative and qualitative data collection techniques was used for the knowledge, attitude and practices study. The data collection methods included interviewing, using a pretested questionnaire, focus group discussions and key informant interviews. To screen the aflatoxin levels in the maize samples from both counties, 144 samples were randomly collected and subjected to the ELISA technique for quantitative detection of aflatoxin B1, B2, G1 and G2. Confirmatory test for the ELISA positive samples was carried out using HPLC analysis. Isolation of fungal strains was done using rose bengal selective media which contained chloramphenicol thereby suppressing bacterial growth. Isolated strains were characterised based on their phenotypic characteristics on the plate and microscopic techniques. Finally, the efficacy of Low temperature nitrogen plasma (LTNP) in destroying fungi and aflatoxin was studied using an experimental design generated using Response Surface Methodology (RSM) of the Box Benken Design (BBD) of the Design Expert software (StatEase, 2020). Independent factors were exposure time, pressure and ionization power whilst percent reduction in both the fungal load and aflatoxin level were the response variables. The results of the knowledge, attitude and

practices (KAP) study revealed a significant difference in the knowledge of factors contributing to aflatoxin contamination in maize. Socio-economic and demographic factors were linear predictors of knowledge ($R2=0.76$, $p<0.001$), whereas they had no effect ($R2=0.043$, $p=0.076$) on the attitude of the maize farmers. Farmers indicated poorly dried maize and poor storage conditions as the main causes of aflatoxin contamination. The aflatoxin analysis on the maize showed that Makueni County had the highest percentage of aflatoxin positive samples with up to 174 ppb. The type of storage condition had a significant effect on the extent of contamination and accounted for 11% of the variation ($R2 =0.11$). Gunny bags were the most common type of storage condition and had the highest level of contamination in both counties whilst metallic bins had the lowest contamination. Strains of Aspergillus flavus, Aspergillus terreus and Aspergillus parasitucus were positively identified after characterization of the isolated strains. Finally the RSM linear model predicted the reduction in fungal load and aflatoxin content with F-values of 7.22 and 15.89 respectively ($P \leq 0.01$). An increase in exposure time and pressure lead to a corresponding decrease in the fungal load and aflatoxin content. Ionization power did not have a significant effect on both response variables. For optimisation of the detoxification process, the RSM model supported process settings of time at 153.58 seconds, pressure of 0.98 Pascals and ionization power of 194.82 Watts. The findings lead to the conclusion that more awareness creation, training of farmers on good agricultural practices, enhanced market surveillance and laboratory services are needed to educate farmers and the general public on dangers related to exposure to aflatoxins. The type of storage condition significantly affects the aflatoxin level in stored maize, proper drying of maize and storage in hermetic structures offers the best method to prevent aflatoxin contamination. Finally, plasma is efficacious in destroying aflatoxins and fungi in the maize to a reduction of 68.78% and 33.89 log (cfu/g) for aflatoxin content and fungal load, respectively. Further the research recommends encompassing temperature as an independent variable in the RSM model to fine tune optimisation parameters.