Thu. Sep 5, 2019

Hall A

Oral Session | Food Safety

[5-1015-A] Food Safety (2)

Chair:Ubonrat Siripatrawan(Chulalongkorn University, Thailand)
10:15 AM - 11:30 AM Hall A (Main Hall)

[5-1015-A-04] **Cinnamon Oil Nanoemulsion as a Natural Microbial Decontaminant of Chilled Fish Flesh**

Piyanan Chuesiang[1,2], Romanee Sanguandeekul[1], *Ubonrat Siripatrawan[1,2] (1. Chulalongkorn University, Department of Food Technology, Faculty of Science(Thailand), 2. The Novel Technology for Food Packaging &Control of Shelf Life Research Group, Chulalongkorn University(Thailand))
10:15 AM - 10:30 AM

[5-1015-A-02] **Application of Fluorescence Spectroscopy for the Classification of honey based on Geographical Origin**

*Abdullah Iqbal[1,2], Mizuki Tsuta[1] (1. Food Research Institute, National Agriculture and Food Research Organization 2-1-12 Kan-nondai, Tsukuba, Ibaraki 305-8642 Japan (Japan), 2. Dept. of Food Technology &Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh(Bangladesh))
10:30 AM - 10:45 AM

[5-1015-A-03] **Preservation of sardine and scallop by high hydrostatic pressure: safety and quality aspects**

*Amauri Rosenthal[1], Rosiane Costa Bonfim[1,2], Fabiano Alves Oliveira[3], Ronoel Luiz de Oliveira Godoy[1], Carlos Adam Conte Junior[4], Eduardo Henrique Miranda Walter[1] (1. Embrapa(Brazil), 2. Federal Rural University of Rio de Janeiro(Brazil), 3. Cefet Valença(Brazil), 4. Federal Fluminense University(Brazil))
10:45 AM - 11:00 AM

[5-1015-A-01] **Assessment of the Handling and Temporary Storage of Yams in Market Places in Ibadan, Oyo State, Nigeria**

*Okwunna Maryjane Umego[1], Habeeb Adedotun Alabi[2], Yahaya Mijinyawa[2] (1. Federal University Oye Ekiti(Nigeria), 2. University of Ibadan(Nigeria))
11:00 AM - 11:15 AM

[5-1015-A-05] **Responsiveness to Food Safety Emergencies in Eswatini following the Outbreak of listeriosis in South Africa**

*Tendekayi Henry Gadaga[1], Anthony N Mutukumira[2] (1. University of Eswatini(Swaziland), 2. Massey University(New Zealand))
11:15 AM - 11:30 AM

Room C

Oral Session | Postharvest/Food Technology and Process Engineering

[5-1015-C] Postharvest/Food Technology and Process Engineering (5)

Chair:Akindele Folarin Alonge(University of Uyo, Nigeria)
10:15 AM - 11:30 AM Room C (3rd room)

[5-1015-C-01] **THE EFFECT OF DRYING METHODS ON THE QUALITY OF TIGER NUT *(Cyperus esculentus lativum)***

*Akindele Folarin ALONGE[1], Edikan Ufot GILBERT (1. University of Uyo(Nigeria))
10:15 AM - 10:30 AM

[5-1015-C-02] **Optimization and Storage Stability Evaluation of Antioxidant Extracts From Batangas Cherry (*Terminalia microcarpa* Decne)**

*Dennis Marvin Opena Santiago[1], Shekayna Eunice Balmes Pacia[1], Jake Lloyd Cabrera Peña[1,2], Claire Solis Zubia[1], Sheba Mae Magbanua Duque[1] (1. Institute of Food Science and Technology, College of Agriculture and Food Science, University of the Philippines Los Banos, College, Laguna 4031 Philippines(Philippines), 2. Department of Science and Technology CALABARZON Region, Regional Science and Technology Center Complex, Jamboree Road, Timugan, Los Banos, Laguna 4030 Philippines(Philippines))
10:30 AM - 10:45 AM

[5-1015-C-03] **Effects of Pre-drying treatment and Drying-air Temperature on Moisture Ratio and Effective Moisture Diffusivity of Tomato (Nigerian Local and Foreign Varieties)**

*Obafemi Ibitayo Obajemihi[1], Joshua Olanrewaju

Olaoye[2], Mayowa Saheed Sanusi[1] (1. Food Engineering Department, University of Ilorin(Nigeria), 2. Agricultural and Biosystems Engineering, University of Ilorin(Nigeria))
10:45 AM - 11:00 AM

[5-1015-C-04] **Extending the Shelf-life of Upland Water Spinach (*Ipomoea aquatica*) Using Trimming, Modified Atmosphere Packaging (MAP) and Low-Temperature Storage**

*Ana Mithuzela Espigol[1], Josephine Agravante[1] (1. Postharvest Horticulture Training and Research Center (PTHRC), College of Agriculture and Food Science (CAFS), University of the Philippines Los Baños (UPLB), Laguna, Philippines(Philippines))
11:00 AM - 11:15 AM

[5-1015-C-05] **Investigation of Cowpea Variety and Storage Methods on Cowpea Beetle Infestation**

*VICTORIA ADA ABODENYI[1], YAHAYA MOBMI MUSA[2], ABDULLAH MUHAMMED BAKO[3] (1. Agricultural Engineering, Federal Polytechnic, Bauchi(Nigeria), 2. Federal polytechnic, Bauchi(Nigeria), 3. 1(Nigeria))
11:15 AM - 11:30 AM

Room D

Oral Session | Others (including the category of JSAM and SASJ)

[5-1015-D] Other Categories (2)

Chair:Tri Yuliana(Universitas Padjadjaran, Indonesia)
10:15 AM - 11:30 AM Room D (4th room)

[5-1015-D-01] **Screening and Enzyme Activity of Cellulose-Producing Bacteria Isolated from Kemiri Sunan (*Reutealis trisperma* (Blanco) Airy Shaw) and Empty Fruit Bunches of Palm Oil**

*Tri Yuliana[1], Efri Mardawati[1], Souvia Rahimah[1], Emilda Ayu Febrianty[1], Agus Try Hartono[1] (1. Univ. Padjadjaran, Indonesia(Indonesia))
10:15 AM - 10:30 AM

[5-1015-D-02] **Development of a Cloud-based Internet of things Monitoring System for Fish Activity and Water Quality in Aquaponics**

*Chien Lee[1], Yu-Jen Wang[1] (1. Department of Mechanical and Electromechanical Engineering, National Sun Yat-sen University(Taiwan))
10:30 AM - 10:45 AM

[5-1015-D-03] **EFFECT OF DIFFERENT MODES OF PLANTING AND WEEDING ON MACHINE FIELD CAPACITY AND YIELD OF A MIXED CROPPING SMALL HOLDER FARM**

Folasayo Titilola Fayose[1], Adesoji Mathew Olaniyan[1], *Babatope Albert Alabadan[1], Anthony Ayodele Fajinmi[1], Kayode Ogunleye[1], Olanrewaju Omoju[1], Olufemi Aladejebi[1], Oluwaseun Ilesanmi[1] (1. Federal University Oye Ekiti(Nigeria))
10:45 AM - 11:00 AM

[5-1015-D-04] **Development of Agro-industrial Worker Trust Assessment System for Sustainable Ergonomic Program in Food Small and Medium-sized Enterprises**

*Mirwan Ushada[1], Nur Achmad Sulistyo Putro[2], Titis Wijayanto[3], Fitri Trapsilawati[3], Nafis Khuriyati[1] (1. Universitas Gadjah Mada, Department of Agro-industrial Technology(Indonesia), 2. Universitas Gadjah Mada, Department of Computer Science and Electronics(Indonesia), 3. Universitas Gadjah Mada, Department of Mechanical and Industrial Engineering(Indonesia))
11:00 AM - 11:15 AM

[5-1015-D-05] **ASSESSING LAND USE TYPES IMPACT ON SOIL ORGANIC CARBON IN SOUTH WEST, NIGERIA**

*OLORUNWA ERIC OMOFUNMI[1], ADESOJI MATTHEW OLANIYAN[1] (1. FEDERAL UNIVERSITY OYE-EKITI(Nigeria))
11:15 AM - 11:30 AM

Oral Session | Food Safety

[5-1015-A] Food Safety (2)

Chair:Ubonrat Siripatrawan(Chulalongkorn University, Thailand)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Hall A (Main Hall)

[5-1015-A-04] Cinnamon Oil Nanoemulsion as a Natural Microbial Decontaminant of Chilled Fish Flesh

Piyanan Chuesiang[1,2], Romanee Sanguandeekul[1], *Ubonrat Siripatrawan[1,2] （1. Chulalongkorn University, Department of Food Technology, Faculty of Science(Thailand), 2. The Novel Technology for Food Packaging &Control of Shelf Life Research Group, Chulalongkorn University(Thailand)）
10:15 AM - 10:30 AM

[5-1015-A-02] Application of Fluorescence Spectroscopy for the Classification of honey based on Geographical Origin

*Abdullah Iqbal[1,2], Mizuki Tsuta[1] （1. Food Research Institute, National Agriculture and Food Research Organization 2-1-12 Kan-nondai, Tsukuba, Ibaraki 305-8642 Japan (Japan), 2. Dept. of Food Technology &Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh(Bangladesh)）
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Keywords: Essential oil, Nanoemulsion , Phase inversion temperature, Antimicrobial , Cell morphology

Economic losses caused by foodborne pathogen and spoilage are a driving force to apply food preservatives in perishable food products. However, the increasing awareness in recent years of the health risks for chemical preservatives added to the increasing demands of consumers for natural antimicrobial agents. This study aimed to develop cinnamon (*Cinnamomum verum*) essential oil nanoemulsion (CEO-NE) as a natural fledgling microbial decontaminant of a chilled fish product. The optimum CEO-NE formulation contained cinnamon essential oil with medium chain triglyceride (MCT) = 10 wt%, a non-ionic surfactant (Tween 80) =15 wt%, and deionized water 75 wt%. The CEO-NE was fabricated using a low energy Phase Inversion Temperature (PIT) method. Sea bass fish flesh was used to represent a seafood product. The fish flesh was artificially contaminated with *Escherichia coli* (ATCC 25922) prior to dipping into the CEO-NE solution at its minimum inhibitory concentration (MIC) determined from the previous experiments. The samples were stored at 4 C. The growth of *E. coli* and total viable counts of the CEO-NE treated samples was examined in comparison to those treated with bulk CEO and untreated (control) samples. The results showed that CEO-NE effectively inhibited *E. coli* and total aerobic bacteria better than bulk CEO. The bacterial cell morphological deformation by the CEO-NE was evidenced by field emission scanning electron microscopy (FE-SEM). The antimicrobial activity of the CEO-NE against *E. coli* was attributed to its ability to disrupt bacterial cell wall structures and promote expulsion of internal cellular material. The results suggest that the encapsulation of cinnamon oil in nanoemulsion enhanced its bactericidal activity against the targeted foodborne microorganism. The developed CEO-NE has potential to be used as natural antimicrobial agent for ensuring food safety of fish flesh or other seafood products.

Oral Session | Food Safety
[5-1015-A] Food Safety (2)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Hall A (Main Hall)

[5-1015-A-02] Application of Fluorescence Spectroscopy for the Classification of honey based on Geographical Origin

*Abdullah Iqbal[1,2], Mizuki Tsuta[1] (1. Food Research Institute, National Agriculture and Food Research Organization 2-1-12 Kan-nondai, Tsukuba, Ibaraki 305-8642 Japan (Japan), 2. Dept. of Food Technology &Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh(Bangladesh))
Keywords: Honey, chemometrics, classification, geographic origin

The Front-face fluorescence spectroscopy was applied in this study for the classification of honey based on geographical origin. Honey samples (*Robinia pseudoacacia* and Blended floral source) of different origin (i.e., China, Hungary and Japan etc) used in this study were collected from their production sites. Before the fluorescence measurement, the samples were put in shaking water bath at 60℃ for 30 min with 100 rpm shaking speed. Then after stirring to obtain the homogeneity, the honey samples were diluted to 100 times with the addition of 20% (v/v) ethanol solution. The front-face fluorescence excitation-emission matrices were then recorded from 200nm to 800nm (at an interval of 1 nm) whereas excitation spectra were recorded between 200nm to 500nm (with an interval of 5nm). With the application of necessary pre-processing (i.e., normalization, mean centering, autoscaling and/or combination thereof) and digital smoothing polynomial filters (i.e., Savitzky-Golay smoothing filters) for smoothing out the noisy signals, the rayleigh scattering rays were removed from the spectra. The chemometric analysis were then applied to the spectral data using principal component analysis (PCA) and partial least squares-discriminant analysis (PLS-DA) for classification of the honey samples. A reasonable sensitivity (ranging from 0.90 to 1.000) and specificity (ranging from 0.795 to 1.000) for class predictions was obtained from the PLS-DA model. The results showed that front-face fluorescence spectroscopy has potential for the discrimination of *Robinia pseudoacacia* honey based on geographical origin. But it is not possible to discriminate the blended samples based on geographical origin.

Application of Fluorescence Spectroscopy for the Classification of Honey Based on Geographical Origin

Abdullah Iqbal[1,2*], Mizuki Tsuta[1]

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ABSTRACT

The Front-face fluorescence spectroscopy was applied in this study for the classification of honey based on geographical origin. Honey samples (*Robinia pseudoacacia* and Blended floral source) of different origin (i.e., China, Hungary and Japan etc) used in this study were collected from their production sites. Before the fluorescence measurement, the samples were put in shaking water bath at 60°C for 30 min with 100 rpm shaking speed. Then after stirring to obtain the homogeneity, the honey samples were diluted to 100 times with the addition of 20% (v/v) ethanol solution. The front-face fluorescence excitation-emission matrices were then recorded from 200nm to 800nm (at an interval of 1 nm) whereas excitation spectra were recorded between 200nm to 500nm (with an interval of 5nm). With the application of necessary pre-processing (i.e., normalization, mean centering, autoscaling and/or combination thereof) and digital smoothing polynomial filters (i.e., Savitzky-Golay smoothing filters) for smoothing out the noisy signals, the rayleigh scattering rays were removed from the spectra. The chemometric analysis were then applied to the spectral data using principal component analysis (PCA) and partial least squares-discriminant analysis (PLS-DA) for classification of the honey samples. A reasonable sensitivity (ranging from 0.90 to 1.000) and specificity (ranging from 0.795 to 1.000) for class predictions was obtained from the PLS-DA model. The results showed that front-face fluorescence spectroscopy has potential for the discrimination of *Robinia pseudoacacia* honey based on geographical origin. But it is not possible to discriminate the blended samples based on geographical origin.

Keywords:
Honey, chemometrics, classification, geographic origin, PCA, PLS-DA

1. INTRODUCTION

Honey is a healthy natural, pure and nutritious food produced by honeybee containing 60–80% of carbohydrates, 17–20% of water, 0.3–0.8% of proteins, 0.2% of minerals and minor quantities of amino acids, phenols, pigments, vitamins, volatile substances, and others (Ball, 2007, Bogdanov et al., 2008, Khan et al., 2017).

Traditionally, honey has been used by human being not only as a nutritious substance but also as a therapeutic product due to its antioxidative components, such as polyphenols, amino and organic acids, enzymes and proteins (Oryan et al., 2016). These components are highly dependent on the floral source, the geographical region of production and external factors associated with environmental conditions, processing and storage methods (Alzahrani et al., 2012). Regional and/or geographical characteristics of honey in terms of the composition varies depending on the climate, altitude and other environmental factors etc (Salonen et al., 2017). Therefore, the geographical origin play an important role in the overall quality and authenticity of honey which is essential to be considered for quality point of view.

Recently, authenticity of foodstuffs became a major issue for the consumers and producers worldwide (Petróczi et al., 2010). In case of honey, authenticity is related to both geographical and floral source determinations as well as detection of unwanted substances, like syrups or sugars. Geographical

origins are economically important and therefore, subjected to frauds, leading to false or doubtful labelling. During the last two decades, several researchers attempted to characterize the botanical and geographical origin of honey by exploiting different analytical techniques (Anklam, 1998), such as FTIR (Wang et al., 2010), FT-Raman spectroscopy (Corvucci et al., 2015), mid-infrared spectroscopy (Ruoff et al., 2006), near-infrared spectroscopy (Woodcock et al., 2007), and fluorescence spectroscopy (Lenhardt et al., 2015, Mehretie et al., 2018). In many cases, several analytical methods are simultaneously essential for a reliable authentication of geographical origin of honeys which is time-consuming, laborious, costly and requires vast technical skill. Therefore, there is a need for new methods which can provides a rapid and reproducible authentication of the geographical origin of honey. As a result, the determination of botanical and geographical origin of honey is of increasing interest worldwide. The use of excitation-emission matrix (EEM) seems to be a promising approach as it has been successfully applied for different products. Fluorescence spectroscopy provides information on the fluorescent molecules' presence and the environment of honey produced like other biological samples. Hence, fluorescence spectroscopy seems to be effective for classification of honey based on geographical origin. Therefore, the aim of the present research is to classify honey collected from different geographical origins using front-face fluorescence spectroscopy.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation for Measurement

A total of 23 honey samples (*Robinia pseudoacacia*) and 49 samples (Blended) produced in different countries (i.e., China, Hungary and Japan, Canada, Argentina and Myanmar) were used in this study. The honey samples were collected from their production sites and stored at 4°C until analysis. Before the fluorescence measurement, the samples were put in shaking water bath at 60°C (for liquefaction) for 30 min with 100 rpm shaking speed. Then after stirring to obtain the homogeneity, the honey samples were diluted to 100 times with the addition of 20% (v/v) ethanol solution. Then 3ml of diluted samples were pipetted into quartz cuvette and placed in the sample holder. The excitation-emission matrices were then recorded with the fluorescence spectrometer (F–7000, Hitachi High–Technologies Corporation, Tokyo, Japan), from 200nm to 800nm (at an interval of 1 nm), whereas excitation spectra were recorded between 200nm to 500nm (with an interval of 5nm). The spectra were then converted into ASCII files to be further analyzed using MATLAB®2019a (The MathWorks, Inc., Natick, MA).

2.2 Processing of Spectra and Multivariate Analysis

With the application of necessary pre-processing (i.e., normalization, mean centering, autoscaling and/or combination thereof) and digital smoothing polynomial filters (i.e., Savitzky-Golay smoothing filters) for smoothing out the noisy signals, the Rayleigh scattering rays were removed from the spectra using a script coded and designed on MATLAB®2019a (The MathWorks, Inc., Natick, MA). The chemometric analysis such as Principal component analysis (PCA) was used to eliminate the spectral collinearity, random noise, and to reduce the dimensionality of variables. It was also applied in visualizing the data set as well as exploring the variations among the sample classes. The data sets in PCA are not correlated with each other and the score plot of the PCA has been used to explain the variations or similarities among the samples (Rahman et al., 2016). Subsequently, the partial least squares-discriminant analysis (PLS-DA) was used for classification of the honey samples. PLS-DA is a classification technique used for building linear discriminant analysis transforming the observed data into a set of intermediate linear latent variables which are then used for predicting the dependent variables. To select the number of PLS variables included in the model, Venetian blind cross-validation was used in this investigation. PCA and PLS-DA of the samples were computed by using the PLS toolbox for MATLAB (Eigenvector Research Inc., Wenatchee, WA, USA).

3. RESULTS AND DISCUSSION

3.1 Spectral information

The excitation-emission matrix (EEM) for typical geographical samples after removing Rayleigh's scattering rays from the spectra are shown in Figure 1(a). It is seen that all the honey samples irrespective of geographical origin, shows three peaks in the contour plot of EEM. The peak exists at around excitation of 230 nm and emission of 340 may be responsible for the fluorescence of aromatic

amino acids (Karoui et al., 2007) present in the honey. The excitation/emission wavelengths corresponding to the peak 280/340 nm, common to all three samples may be due to the presence of flavonoids (such as apigenin, chrysin, kaempferol, pinocembrin), although it is tough to identify the flavonoids responsible for such peaks (Lenhardt et al., 2015). Another fluorescence peak corresponding to excitation wavelength range of 320-340 nm and emission wavelength range of 400-460 nm could be related to the Maillard reaction products such as hydoxymethylfurfural and furosine (Lenhardt et al., 2015). The contour plot of spectra for the *Robinia pseudoacacia* samples generally indicates that the considered honey samples may have similar components although they are originated or produced in different countries. However, the variation in peaks may be due to the concentration of different components.

The spectral behavior of blended honey samples is bit complex and there are distinct differences among the samples. Even the samples blended in the same geographical location (i.e., samples from same country), the different blended samples gave different fluorescence signatures as shown in figure 1(b). This may be due to the ingredient of the blended components and their concentration as well as other parameters associated with the blending process which cannot be explained unknown during the investigation.

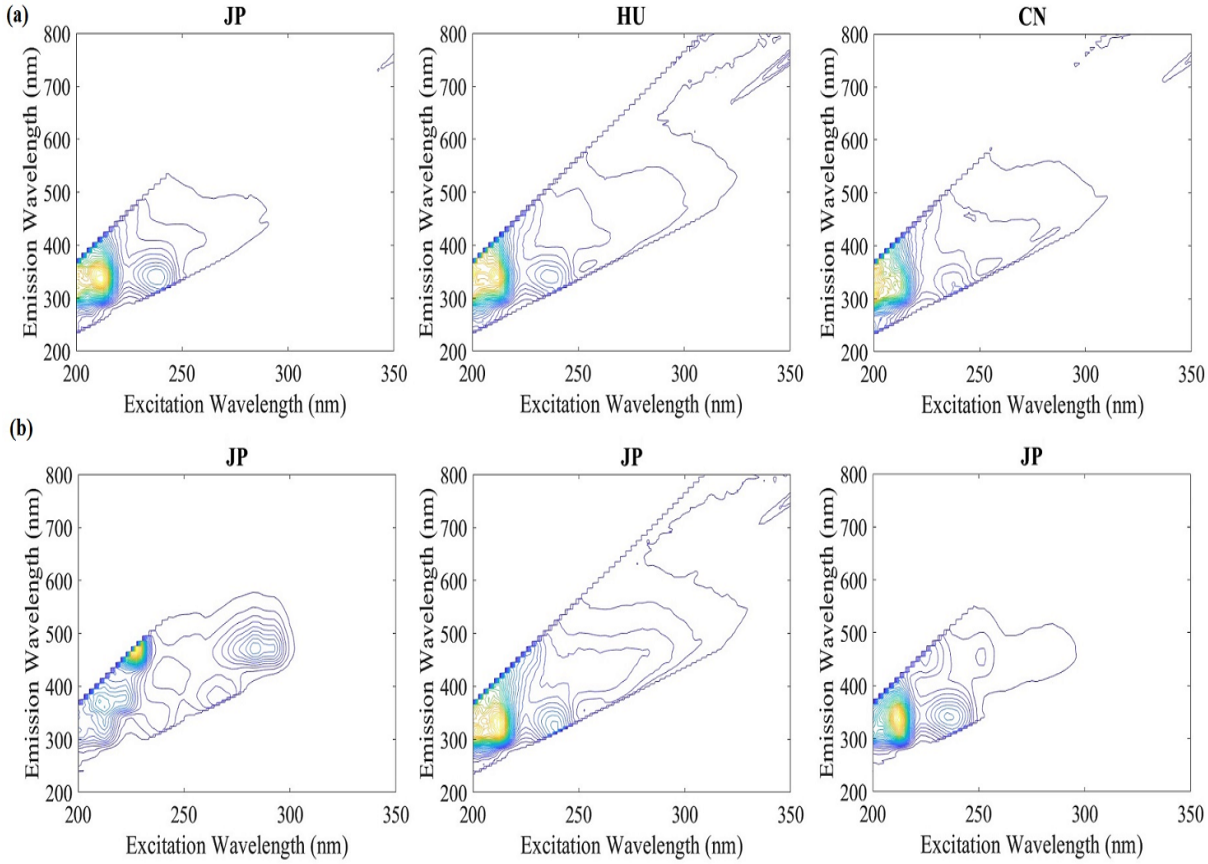

Figure 1. Excitation-emission spectra of different honey*: (a) Robinia pseudoacacia, (b) Blended
(*JP=sample from Japan, HU= sample from Hungary, CN=sample from China)

3.2. Chemometric analysis

3.2.1 Principal component analysis (PCA)

PCA is applied for both types of honey samples (*Robinia pseudoacacia* and blended) to reduce multidimensionality to two dimensions and the results are shown in Figure 2. From the PC scores it is seen that for the pseudoacacia samples (Figure 2.a), the PC1 explained 63.80% of the total variance in the data set while PC2 explained 17.46% and remaining 18.74% of data variance belongs to the other dimensionality. From the score plot, the honey samples are not completely separated into different classes or groups. It is seen from the plot that they are very close to each other (as it is mentioned earlier that showing similar peaks). The similar but more prominent behavior has been observed for

the blended sample as shown in Figure 2(b), although the PC1 explained 61.23% of the total variance in the data set while PC2 explained 18.33% whereas remaining 20.44% of data variance belongs to the other PCs.

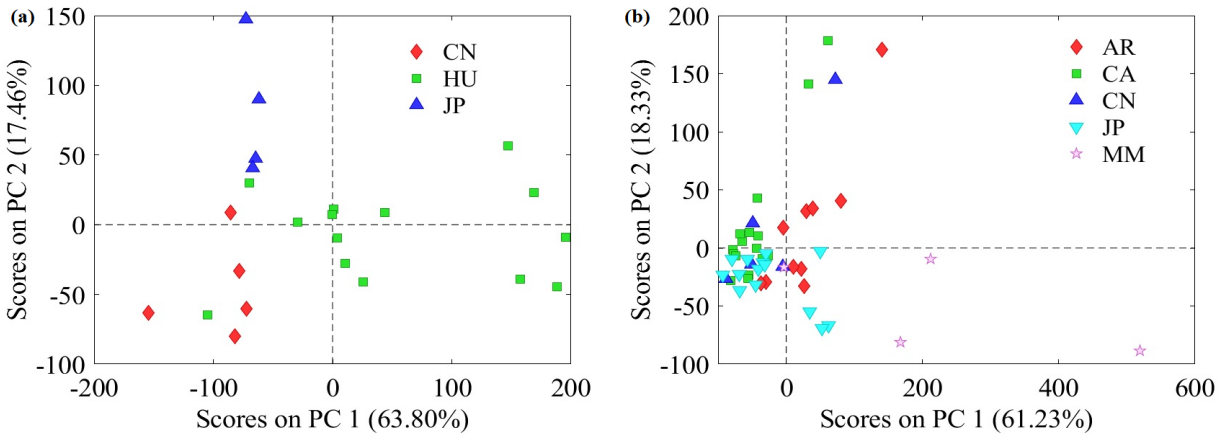

Figure 2. Two dimensional PCA score plots of honey*: (a) Robinia pseudoacacia (b) Blended

(*CN=sample from China, HU=sample from Hungary, JP= sample from Japan, CA=sample from Canada, MM=sample from Myanmar)

3.2.2 Partial least squares-discriminant analysis (PLS-DA)

The PLS-DA classification model was developed to classify different honey samples based on geographical origin and four parameters such as sensitivity, specificity for calibration (Cal), and cross-validation (CV) were considered as the indicator of the robustness of the model (Table 1).

Table 1. Sensitivity, specificity, and classification error of PLS DA models.

Parameters*	Robinia pseudoacacia	Blended
Sensitivity (Cal)	1.000	0.900
Sensitivity (CV)	1.000	0.900
Specificity (Cal)	1.000	0.872
Specificity (CV)	0.944	0.795

*Cal refers to calibration set, and CV refers to the cross-validation results

The best model was built with 5 and 4 latent variables for pseudoacacia and blended samples, respectively. The models showed reasonable sensitivity (from 0.900 to 1.00 for both Cal and CV) and specificity (0.795 to 1.00 for Cal and 0944 for CV) for the classification of honey samples for both the the Pseudoacacia and blended samples (Table-1). The confusion table (CV) for both types of honey samples are shown in Table 2.

Table 2. Confusion table for honey samples

Predicted as...	Actual Class *(Robinia pseudoacacia)*		
	CN (5)	HU (14)	JP (4)
China (CN)	5	1	0
Hungary (HU)	0	13	0
Japan (JP)	0	0	4

Predicted as…	Actual Class (Blended)				
	AR (10)	CA (16)	CN (5)	JP (14)	MM (4)
Argentina (AR)	9	3	1	2	0
Canada (CA)	1	8	2	2	0
China (CN)	0	4	1	0	0
Japan (JP)	0	1	0	10	0
Myanmar (MM)	0	0	1	0	4

From table-2, it is seen that *Robinia pseudoacacia* samples can be classified based on geographical origin. But for the blended honey, samples only from Argentina and Myanmar, has been classified as the origin they belong. Remaining samples are mixed with other classes which seems to be like that group(s) as described in section 3.1.

4. CONCLUSION

This study was conducted to demonstrate the potential application of excitation-emission matrix (EEM) patterns for the classification of complex matrix of honey samples from different geographical origin. The front face fluorescence measurement used in this study revealed that it is not possible to obtain complete classification of honey based on geographic origin by Front-face fluorescence spectroscopy. Although the classification accuracy for pseudoacacia samples was reasonable but not up to the level for the blended samples to conclude with a sentence 'complete classification' is possible! However, further studies need to be carried out with the modification of existing Front-face fluorescence spectroscopy with more samples to make a conclusion about the potential for the classification of honey based on geographic origin.

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The authors acknowledge the financial and logistic supports provided by Japan International Cooperation Agency (JICA), Kirin Holdings Company, Limited, Food Research Institute, National Agriculture and Food Research Organization (NARO), Japan and Bangladesh Agricultural University, Mymensingh, Bangladesh to carry out this research.

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10:45 AM - 11:00 AM (Thu. Sep 5, 2019 10:15 AM - 11:30 AM Hall A)

[5-1015-A-03] Preservation of sardine and scallop by high hydrostatic pressure: safety and quality aspects

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Keywords: Sardine, Scallop, High Hydrostatic Pressure, Preservation, Shelf life

High hydrostatic pressure (HHP) has been a successful novel technology for preservation of different foods, including seafood and fishes. However, safety and quality aspects have to be considered for designing a proper process aiming at optimizing the quality and assuring the safety of the products. Some studies have been carried out for comparing quality and safety aspects of sardine and "Lion Paw" scallop muscle processed by HHP. Therefore, sardine fillets and scallops muscle were treated by 300 MPa to 400 MPa for 0 to 15 min. and compared regarding microbiology, TBARS, N-TVB formation and nucleotide degradation along refrigerated (4-5^{o}C) shelf-life. In the case of sardines, HHP did not completely cease N-TVB formation and nucleotide degradation, but minimized the development of those processes, especially at higher pressure levels and holding times. Regarding scallops, HHP decreased the count of mesophilic and psychotropic microorganisms below the legislation standard requirements. However, proper caution should be taken mainly considering specific pathogenic microorganisms. As expected, HHP accelerated lipid oxidation in the case of scallops, resulting in increase of TBARS, but did not exceed the standard limit of 2 mg/kg. Nucleotide degradation followed different patterns considering the different metabolisms and specificities of the muscle fibers. These results indicate that HHP can significantly increase the refrigerated storage time for sardine and scallop but intrinsic and extrinsic factors and characteristics may influence the safety and quality aspects.

Oral Session | Food Safety
[5-1015-A] Food Safety (2)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Hall A (Main Hall)

[5-1015-A-01] Assessment of the Handling and Temporary Storage of Yams in Market Places in Ibadan, Oyo State, Nigeria

*Okwunna Maryjane Umego[1], Habeeb Adedotun Alabi[2], Yahaya Mijinyawa[2] (1. Federal University Oye Ekiti(Nigeria), 2. University of Ibadan(Nigeria))

Keywords: Yam, Yam Storage, Open Shed, Yam Stall

Yams are scarce during non-harvest seasons and the prices are exorbitant with majority of the population unable to buy. This situation motivated the interest for this research to assess the handling of yam and the temporal storage practices among traders in order to identify and have good understanding of the various activities pertaining to the yam markets. Visits to the markets, interview with the traders and measurement of the storage temperature and relative humidity were carried out to obtain data for the assessment of handling and temporal storage of yams in the markets. Five activities were identified pertaining to yams in the markets, namely: arrival of yams in vehicles, unloading of the yams, display of the yams for sale, packaging and loading of sold yams, and lastly temporal storage of the unsold tubers. The assessment of the handling of yam tubers in each of the above mentioned activities revealed that; the handling operations are rudimentary and results in bruising, breakage and exposure of tubers to adverse environmental conditions thereby causing substantial losses. The assessment of the temporal storage structures for yams in the markets showed that; there are two types of storage structures for yams in the markets, these are: the open shed and the market stalls. The storage environment, the design and construction materials of these storage structures are not effective for yam, thereby contributing to losses. These findings revealed that the open shed and market stall rooms used by yam wholesalers in Bodija and Bere-Mapo markets are ineffective for yam storage because the storage environment within these structures as influenced by the design and construction materials cannot allow for effective storage of yams. The problems associated with these structures in percentage are roof leakage 34.8% and 11.4%, rodent and pest attacks 82.6% and 11.4%, and adverse environmental conditions 91.3% and 85.7% for open sheds and stalls respectively. It is recommended that the materials of construction and design of these structures be modified to make them more effective.

Assessment of the Handling and Temporary Storage Methods of Yams in Market Places in Ibadan

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ABSTRACT

Yams are scarce during non-harvest seasons and the prices are exorbitant with majority of the population unable to buy. This situation motivated the interest for this research to assess the handling of yam and the temporal storage practices among traders in order to identify and have good understanding of the various activities pertaining to the yam markets. Visits to the markets, interview with the traders and measurement of the storage temperature and relative humidity was carried out to obtain data for the assessment of handling and temporal storage of yams in the markets. Five activities were identified pertaining to yams in the markets, namely: arrival of yams in vehicles, unloading of the yams, display of the yams for sale, packaging and loading of sold yams, and lastly temporal storage of the unsold tubers. The assessment of the handling of yam tubers in each of the above mentioned activities revealed that; the handling operations are rudimentary and results in bruising, breakage and exposure of tubers to adverse environmental conditions thereby causing substantial losses. The assessment of the temporal storage structures for yams in the markets showed that; there are two types of storage structures for yams in the markets, these are: the open shed and the market stalls. The storage environment, the design and construction materials of these storage structures are not effective for yam, thereby contributing to losses. These findings revealed that the open shed and market stall rooms used by yam wholesalers in Bodija and Bere-Mapo markets are ineffective for yam storage because the storage environment within these structures as influenced by the design and construction materials cannot allow for effective storage of yams. The problems associated with these structures in percentage are roof leakage 34.8% and 11.4%, rodent and pest attacks 82.6% and 11.4%, and adverse environmental

conditions 91.3% and 85.7% for open sheds and stalls respectively. It is recommended that the materials of construction and design of these structures be modified to make them more effective.
Keywords: Open shed, Yam stall, Yam storage, Yam

1. INTRODUCTION

Nigeria is the largest producer of yams in the world, annually producing about 31 million tonnes. Nigeria produced 60% of the world's yams in 2010, and is the largest contributor in Africa's "Yam Belt," a yam production area that comprises Nigeria, Ghana, Benin, Côte d'Ivoire, Central African Republic, Cameroon, and Togo. Yams have had the second highest production level of any food crop in Nigeria in the past 50 years after cassava (Bergh *et al.*, 2012). Yam losses are one of the greatest problems facing yam production in Nigeria and are of concern to everyone, from the research scientists to the extension workers, marketers in the field to the farmers on the farm and to the government policy formulators. The post-harvest handling and storage practices for yams in Nigeria presents a dismal picture and are mostly comprised of traditional techniques practiced by growers, traders and the processor resulting in considerable deterioration of physical and nutritional qualities of harvested crop (Oni and Obiakor, 2002). Interest in the reduction of post-harvest losses is not new. Mrema and Rolle (2002) reported that after the mid-1970s food crisis, the United Nations brought post-harvest storage losses into international focus in 1975 when it declared that "further reduction of post-harvest food losses in developing countries should be undertaken as a matter of priority". In underdeveloped and developed tropical countries, both quantitative and qualitative losses of agricultural products occur at all stages in the post-harvest chain, from harvesting, through handling, storage, processing, packaging, transportation and marketing until crops are delivered to the final consumers.

Ibadan North local Government is a big urban center with a population of over 350,000 inhabitants, according to the 2006 Nigerian census (NPC, 2006). The town is home to two major urban yam markets in Oyo State, that is, Bodija and Bere-Mapo yam markets. According to the Natural Resources Institute (NRI, 2012) report, diverse challenges constrain yam farmers and marketers' ability to fully exploit the potential of yams and yam products in the southwest, these includes, high cost of inputs and labour, lack of credit, limited access to proper secure storage facilities, high transportation costs and ineffective handling practices. The yam traders in Ibadan North are no exception to the above mentioned challenges.

Despite the elaborated agricultural programs, Ibadan is still unable to provide an all year round supply of yams within the purchasing power of majority of the people. Besides economic factors, the supply of food in the local government is limited by losses due to wastage and spoilage. Though no one knows how much yams is lost between harvest and consumption, but post-harvest management complements efforts to enhance food security through improved farm level productivity, thus tending to benefit producers, and more specifically, the rural farmers.

Post-harvest management reduces post-harvest losses thus, generates income, improves product quality and safety, and contributes to food and nutritional security. It is against this background that an analysis of the post-harvest management strategies like handling and temporary storage by yam traders is deemed important. This work assessed the handling and temporary storage of yams in markets in Ibadan North local government

2. METHODOLOGY

2.1 Study Area

This study was carried out in Ibadan North Local Government area. The city of Ibadan is located approximately on longitude $3^0$5" E of the Greenwich Meridian and latitude $7^0$23" N of the Equator. Economic activities undertaken by people in the Local Government Area include trading, public service and agriculture. Ibadan North Local Government has a land area of 145.58km^2 and a population of 306,795 people (NPC, 2006). The study area experiences a tropical type of climate. It has a mean annual temperature of about 32^0 C. The relative humidity can be as high as 95% and a total of about 1250 mm as mean annual rainfall.

2.2 Methodology

The markets were visited for physical observation of the activities taking place, particularly among the yam wholesalers. Also, the yam storage structures were assessed. Temperature and relative humidity of the storage structures and the ambient environment were measured once every other day for a period of one month (August 19th to September 16th, 2016). A dry bulb and wet bulb thermometer with psychrometric chart was used to achieve this. A questionnaire was designed to obtain information on some of the questions regarding yam storage among yam wholesalers in Bodija and Bere-Mapo markets. The data collected was analyzed using the Microsoft Excel 2010 to obtain statistics of frequencies and percentages of the data.

3. RESULTS AND DISCUSSIONS

3.1 Arrival of Yams to the Markets

Yams are transported from the farms or small local district markets in rural areas to the large urban markets of Bodija and Bere-Mapo in big lorries, buses, open pick-up vans, and trucks. It was observed that, yams are stacked one upon another like timber, without any packaging material. Yams that are in contact with the edges of the vehicle sustained abrasions and cuts, those at the bottom are subjected to compressive loads due to the weight of the overburdening yams lead to internal injury or damage of the yams at the bottom. Depending on the degree of injury on the yam, the level of periderm formation might be affected. When the periderm is not formed the yam cannot heal the bruised part, thus, the storage life is reduced.

3.2 Unloading Operation

This operation is carried out manually by the market labourers. The labourers unload the vehicles either by using metal pans to pack the yams from the vehicle or by throwing the yams from the vehicle to other labourers standing on the ground who then place it on the ground gently. Unloading by throwing if not done carefully can lead to breakage (figure 1). In the case of unloading with the metal pan, there is risk of compression damage due to the force acting on individual tubers. It was also observed that the labourers carry plenty yams at a time and get fatigue under the weight. Thus, instead of gently putting down the tubers they drop it by pouring. This results in tuber bruises and breakages.

Figure 1: Unloading operation by throwig

3.4 Packaging and Loading of Sold Yams

Sometimes the market labourers are contracted to carry the yams to the vehicle. The practice of loading yams in the vehicle by pouring before arranging as shown in figure 2 is damaging to the yams. Some yams break and others get bruised and as a result such tubers do not take long to spoil. As recommended by Ayoub and Lennox (2013), packaging materials such as telescopic fiberboard cartons with paper wrapping or excelsior should be used. This reduces bruising and damage due to heat from the tuber respiration and breakage and internal injury caused by compression of tubers from the weight of the overlying tubers.

Figure 2: Loading operation by pouring

3.5 Temporal Storage of Yams in Markets

The markets are not used for long storage of yams, however, there is yam storage in the markets on a temporary basis. This is because tubers are usually supplied in very large quantities and the supplies are usually not exhausted in a few days. Sometimes it takes over a month before some traders are able to exhaust their supplies. Thus, there is storage of the produce while the stock lasts.

3.5.1 Types of Yam Storage Structures

There are only two types of yam storage structures in Bodija and Bere-Mapo markets in Ibadan North local government, Oyo State. In Bodija yam market, wholesalers use open sheds (figure 3) to store yams, while those in Bere-Mapo yam market, use stalls as structures for yam storage (figure 4). These structures can best be described as improvised yam storage structures as the design and types of construction materials are not in tandem with any known design criteria or principle for yam storage structures. However, traders have been using these structures for years for the storage of yams. These structures were assessed to see how they vary from known traditional and modern yam storage structures, and what improvements they need to become effective in storing yams.

Figure 3: Open shed

Figure 4: Yam Stall

3.5.2 Storage Environment of the Structures

The average daily ambient temperatures and the temperatures inside the open shed in Bodija and the market store rooms in Bere-Mapo yam markets are presented in figures 5 and 6. While the temperatures in the open shed storage structures varied from 25.3^{0}C to 30.3^{0}C with an average value of 28.03^{0}C and an average ambient temperature of 28.67^{0}C, those within the stall rooms varied from 30.1^{0}C to 33.8 ^{0}C with an average value of 33.21^{0}C, and for the ambient temperatures, the range is from 26.0^{0}C to 33.0^{0}C with an average value of 29^{0}C. The temperatures within the open shed was generally equal to that of the ambient conditions, but lower than those obtained in the market stall rooms for all periods throughout the study

period. These average temperature values are higher than the storage temperature of 13^0C to 15^0C for yam recommended by the National Agriculture Research Institute, 2004.

The ambient relative humidity ranged from 76% to 82% with an average value of 79.73%, while for the open shed, it varied from 79% to 83% with an average value of 80.10%, and for the stall rooms it varied from 82% to 88% with an average value of 85.15%. Although, there were a few overlaps, the ambient relative humidity was equal to those in the open shed structure but lower than those within the market store rooms (figures 7 and 8). However, these average relative humidity are lower than the recommended value of 90% to 95% by the National Agriculture Research Institute, 2004.

The variation in the environmental conditions within the market stall rooms and the open shed structure is attributed to the lack of ventilation in the store rooms, material of construction and the arrangement of the yams in the store rooms. This observation is due to the fact that within the stall room storage structures, the respiration of the tubers of yam increased the internal temperatures of the structures which is not the case under the open shed environment.

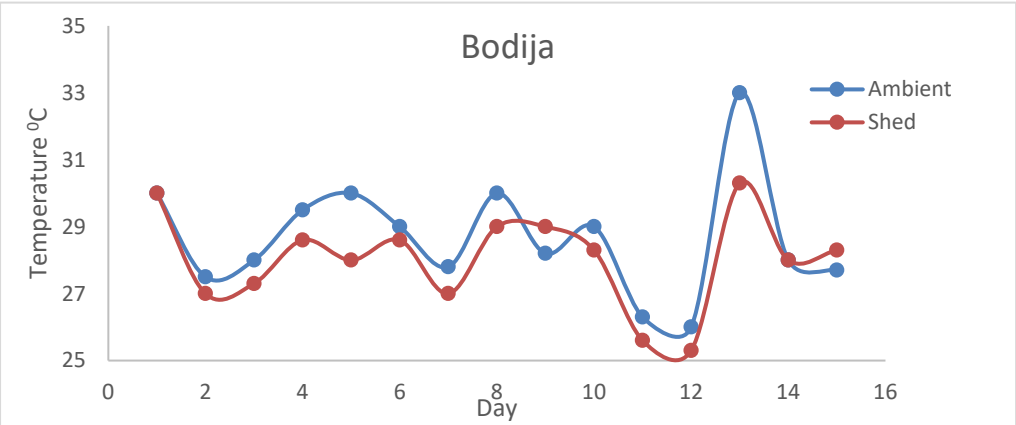

Figure 5: Average Daily Temperatures of Yam Storage Structures in Bodija

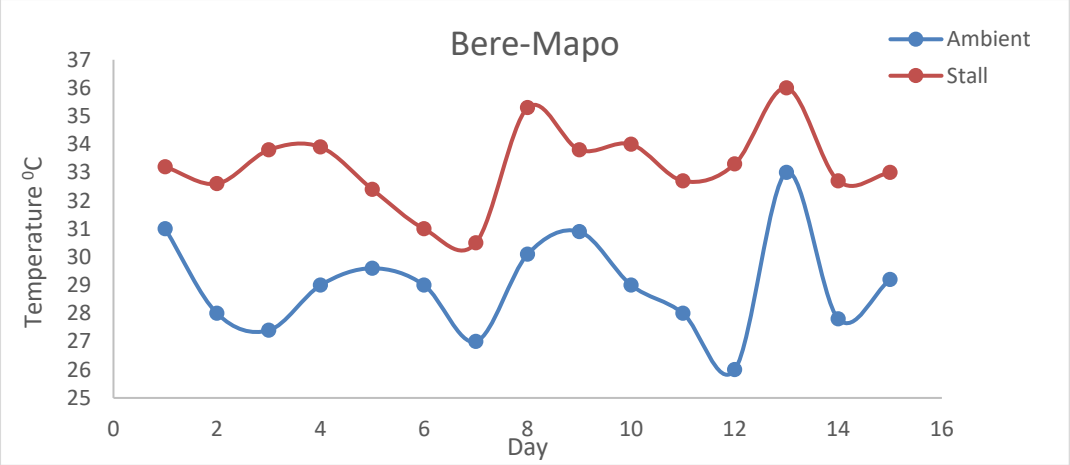

Figure 6: Average Daily Temperatures of Yam Storage Structures in Bodija

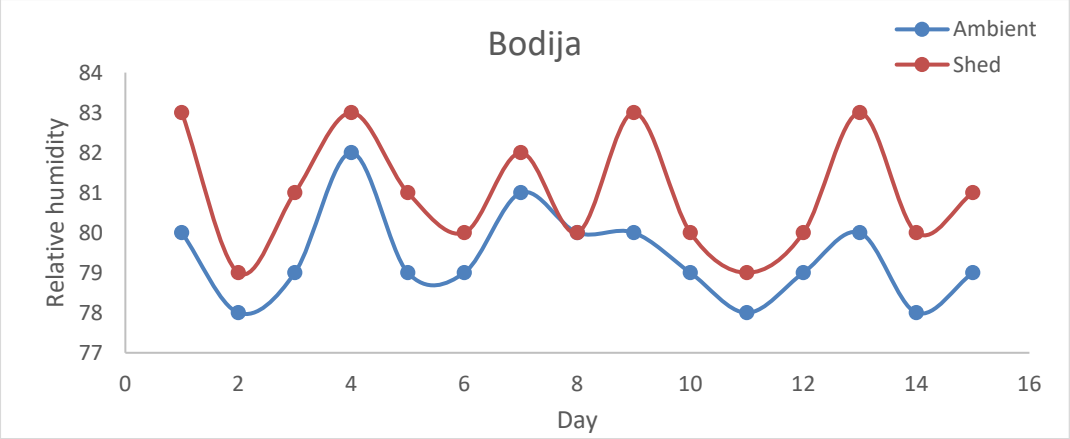

Figure 7: Average Daily Relative Humidity of Yam Storage Structures in Bodija

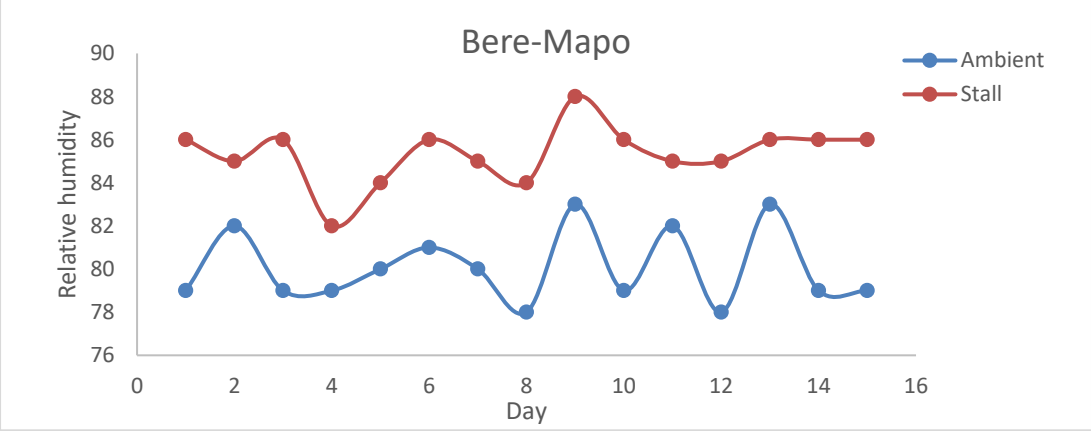

Figure 8: Average Daily Relative Humidity of Yam Storage Structures in Bere-Mapo

3.5.3 Storage Structure Construction Materials

The materials of construction are wood, sand and cement blocks walls, the roof is corrugated zinc or aluminum roofing sheets and ventilation is inadequate because only one opening, which is the door, is fitted on the store. These construction materials are not very good insulators of heat. The roofing sheets for example, easily conducts solar heat and transmits it easily into the room as no ceiling is provided and the height is low (2.3 meters). The arrangement of the yams in the stalls by heaping does not permit maximum air circulation between the tubers as compared to the arrangement in the open sheds. This is detrimental to the tubers because, during respiration of yams, oxygen is used and CO_2, water and heat are produced. Since there is no proper air circulation to transport the heat and water away from the tubers, the heat causes rise in temperature and water increase the moisture in the air, which is the relative humidity Physiological activities like respiration and sprouting of the tubers are promoted by high temperature of the storage environment which results in a steady loss of carbohydrate in the form of carbon dioxide and water, making the yams to lose weight, size and market value.

3.5.4 Problems Associated with the Temporal Storage Structures

The problems associated with yam storage structures in Bodija and Bere-Mapo yam Markets are presented in Table 1. The results indicate that environmental factors constitute a major problem in both markets. While for Bodija market, 91.3% of the respondents said storage environment conditions within the open shed was not favorable for yam storage, for Bere-Mapo market, 85.7% attributed yam storage losses to adverse environmental conditions within the store rooms. Decay was very high in tubers heaped on floor as a result of direct contact with the soil on the bare ground. Presence of rot pathogen in soil on the storage area serves as a source that initiates decay. Poor air circulation within the heaped yam aid in the build-up of heat and increase humidity as a result of respiration. Hence induces spore germination and growth of pathogens.

Another major problem is the incidence of pest and rodents attacks which is particularly high (82.6%) in the open shed, but low in the market stall rooms with 11.4%. This high variation is attributed to the fact that in the market stalls, the rooms are fumigated and the doors are closed and rat poisons are used in preventing rodents and other pests from damaging the stored yams. However, within the open sheds, fumigation is not effective because the structure has no enclosure. Rat poisons are used against rodent attacks, but soon afterwards,

another set of rodents migrate from the nearby refuse dump sites and bushes to attack the stored yams since they are kept in the open space.

Other storage problems identified are roof leakage and storage space. While in Bodija 34.8% of sheds assessed had the problem of roof leakage, those within Bere-Mapo is 11.4%. Roof leakage allows direct sun rays and rain water to impact on the stored tubers. The continuous heating and wetting of the tubers result in breaking yam dormancy period sooner than necessary. Once dormancy period is over, sprouting sets in. Sprouting of stored yams is not desired because it affects the nutrition and size of the tuber. It can also result to decay of the yam and after its viability. Also, roof leakage increases the relative humidity within the storage environment and in combination with high temperature, encourages mold growth and insect activity.

Table 1: Problems Associated with Yam Storage Structure in Bodija and Bere-Mapo Markets.

Problems	Frequency(n=23)	Bodija	Frequency(n=35)	Mapo
Leakages	8	34.8%	5	14.3%
Collapse	1	4.3%	-	-
Rodents Attack	19	82.6%	7	20%
Environmental Factors	21	91.3%	30	85.7%

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The assessment of the handling of yam tubers in each of the above mentioned activities reveals that; the handling operations are rudimentary and results in bruising, breakage and damage of the yams causing substantial losses.

Furthermore, this study reveals that, there are only two types of temporal storage structures for yams in Bodija and Bere-Mapo yam markets, that is, the open shed and market stalls structures respectively. The assessment of these methods of yam storage structures shows that they are not efficient methods for yam storage because, the design and types of construction materials used cannot significantly moderate the storage temperature and relative humidity of the stored yams. Also, the design does not provide the means for protecting the stored yam

tubers from rodents and other insects attack. Roof leakage, rodents attack, collapse, and harsh environmental conditions were some of the problems with these temporal storage structures

4.2 Recommendations

Proper handling of yams should be adopted both by farmers and wholesalers to minimize losses. The stall room used for yam storage should be well ventilated in order to enhance the exchange of air between the enclosure and the surroundings thereby eliminating the enzymatic action and micro-organism activities which result in the rapid spoilage of stored produce. Markets storage structures should be modified by adopting the design and types of construction materials recommended by Nigerian Stored Produce Research Institute (NISPRI).

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Oral Session | Food Safety
[5-1015-A] Food Safety (2)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Hall A (Main Hall)

[5-1015-A-05] Responsiveness to Food Safety Emergencies in Eswatini following the Outbreak of listeriosis in South Africa

*Tendekayi Henry Gadaga[1], Anthony N Mutukumira[2] (1. University of Eswatini(Swaziland), 2. Massey University(New Zealand))

Keywords: food safety, listeriosis, Eswatini, food control, pathogens

The FAO defines food safety as the absence, or safe, acceptable levels of hazards in food that may harm the health of consumers. Microbiological hazards pose a disproportionate threat to human health in all countries, more so in developing countries due to inadequate resources and fragmented food control systems. The food control system in Eswatini is administered by different departments. The Ministry of Health is responsible for the administration of the Public Helath Act; Ministry of Agriculture, the Dairy act, and the Ministry of Trade, Industry and Commerce, standards, including food standards. A 2013 Food Safety Bill that aims at coordinating food control activities under a single food control authority has yet to be finalised. The outbreak of listeriosis in South Africa in 2017 revealed the importance of an effective food control system in Eswatini. Under the current food control system, the country runs the risk food poisoning outbreaks that may be difficult to control. Like other countries in southern Africa, Eswatini depends on South africa for substabtial amounts of its food requirements, including cereals, fruits, vegetables, and meat products. Brands of ready-to-eat cold meat products that were implicated in the listeriosis outbreak in South Africa are also marketed in Eswatini. As a strategy to prevent the spread of the outbreak in Eswatini, the Ministry of Health embarked on a consumer awareness campaign and initiated a recall of affected products. The country had no capacity to test the products to verify presence of Listeria monocytogenes, thereby highlighting the need to strengthen the food control system. This paper reviews the state of the food control system in Eswatini and assesses the readiness of the country to respond to food safety emergencies using the listeriosis outbreak in South Africa as a case study.

Responsiveness to Food Safety Emergencies in Eswatini following the Outbreak of listeriosis in South Africa

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ABSTRACT

The FAO defines food safety as the absence, or safe, acceptable levels, of hazards in food that may harm the health of consumers. Microbiological hazards pose a disproportionate threat to human health in all countries, more so in developing countries due to inadequate resources and fragmented food control systems. The food control system in Eswatini is administered by different departments. The Ministry of Health is responsible for the administration of the Public Health Act, Ministry of Agriculture, the Dairy Act, and the Ministry of Trade, Industry and Commerce is responsible for standards, including food standards. A 2013 Food Safety Bill that aims at coordinating food control activities under a single food control authority has yet to be finalised. The outbreak of listeriosis in South Africa in 2017 revealed the importance of an effective food control system. Under the current food control system, Eswatini runs the risk of food poisoning outbreaks that may be difficult to control. Like other countries in southern Africa, Eswatini depends on South Africa for substantial amounts of its food requirements, including cereals, fruits, vegetables, and meat products. Brands of ready-to-eat cold meat products that were implicated in the listeriosis outbreak in South Africa in 2017 are also marketed in Eswatini. As a strategy to prevent the spread of the outbreak in the country, the Ministry of Health embarked on a consumer awareness campaign and initiated a recall of affected products. The country had no capacity to test the products to verify presence of *Listeria monocytogenes*, thereby highlighting the need to strengthen the food control system in Eswatini. This paper reviews the state of the food control system in Eswatini and assesses the readiness of the country to respond to food safety emergencies, using the listeriosis outbreak in South Africa as a case study.

Keywords: Food safety, listeriosis, Eswatini, Food control, pathogens

Oral Session | Postharvest/Food Technology and Process Engineering

[5-1015-C] Postharvest/Food Technology and Process Engineering (5)

Chair:Akindele Folarin Alonge(University of Uyo, Nigeria)

Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room C (3rd room)

[5-1015-C-01] THE EFFECT OF DRYING METHODS ON THE QUALITY OF TIGER NUT *(Cyperus esculentus lativum)*

*Akindele Folarin ALONGE[1], Edikan Ufot GILBERT （1. University of Uyo(Nigeria)）

10:15 AM - 10:30 AM

[5-1015-C-02] Optimization and Storage Stability Evaluation of Antioxidant Extracts From Batangas Cherry (*Terminalia microcarpa* Decne)

*Dennis Marvin Opena Santiago[1], Shekayna Eunice Balmes Pacia[1], Jake Lloyd Cabrera Peña[1,2], Claire Solis Zubia[1], Sheba Mae Magbanua Duque[1] （1. Institute of Food Science and Technology, College of Agriculture and Food Science, University of the Philippines Los Banos, College, Laguna 4031 Philippines(Philippines), 2. Department of Science and Technology CALABARZON Region, Regional Science and Technology Center Complex, Jamboree Road, Timugan, Los Banos, Laguna 4030 Philippines(Philippines)）

10:30 AM - 10:45 AM

[5-1015-C-03] Effects of Pre-drying treatment and Drying-air Temperature on Moisture Ratio and Effective Moisture Diffusivity of Tomato (Nigerian Local and Foreign Varieties)

*Obafemi Ibitayo Obajemihi[1], Joshua Olanrewaju Olaoye[2], Mayowa Saheed Sanusi[1] （1. Food Engineering Department, University of Ilorin(Nigeria), 2. Agricultural and Biosystems Engineering, University of Ilorin(Nigeria)）

10:45 AM - 11:00 AM

[5-1015-C-04] Extending the Shelf-life of Upland Water Spinach (*Ipomoea aquatica*) Using Trimming, Modified Atmosphere Packaging (MAP) and Low-Temperature Storage

*Ana Mithuzela Espigol[1], Josephine Agravante[1] （1. Postharvest Horticulture Training and Research Center (PTHRC), College of Agriculture and Food Science (CAFS), University of the Philippines Los Baños (UPLB), Laguna, Philippines(Philippines)）

11:00 AM - 11:15 AM

[5-1015-C-05] Investigation of Cowpea Variety and Storage Methods on Cowpea Beetle Infestation

*VICTORIA ADA ABODENYI[1], YAHAYA MOBMI MUSA[2], ABDULLAH MUHAMMED BAKO[3] （1. Agricultural Engineering, Federal Polytechnic, Bauchi(Nigeria), 2. Federal polytechnic, Bauchi(Nigeria), 3. 1(Nigeria)）

11:15 AM - 11:30 AM

Oral Session | Postharvest/Food Technology and Process Engineering
[5-1015-C] Postharvest/Food Technology and Process Engineering (5)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room C (3rd room)

[5-1015-C-01] THE EFFECT OF DRYING METHODS ON THE QUALITY OF TIGER NUT *(Cyperus esculentus lativum)*

*Akindele Folarin ALONGE[1], Edikan Ufot GILBERT （1. University of Uyo(Nigeria)）
Keywords: Drying methods, quality, tiger nuts, moisture content, properties

This study aimed at evaluating the effect of different drying methods on the quality of tiger nut (*cyperus esculentum lativum*). Three drying methods: sun drying, oven drying and microwave-oven drying were employed. Analysis of proximate, minerals, anti-nutrient and anti-oxidant composition of fresh (control) and dried tiger nut were carried out using the official method of analysis byt the association of analytical chemist (AOAC, 2010). Fresh tiger nut tubers were divided into four portions. Three of the four portions were dried to constant weight using sun, oven and micro-wave drying methods respectively. The fourth portion of the sample was not dried but serves as the control. Result showed that the proximate composition of fresh and dried tiger nut sample for moisture content ranged from (5-45%), Protein (1.04-3.50%), Ash (0.05-0.51%), fibre (3.69-5.04%). fat (23.48-24.11%). For the dried samples, microwave oven drying had the lowest moisture (5.0%), oven had the highest fibre (3.80%), oven had the highest ash (0.48%), oven had the highest fat (24.11%), and oven had the highest protein (3.50%) contents contents. These values were significantly different from ($p<0.05$) the control. The minerals composition of the fresh and dried tiger nut ranged from Calcium (1.97mg/g-2.41mg/g), Potassium (2.29mg/g-3,83mg/g), Magnesium (1.03mg/g-5.33mg/g), and Zinc (5.09mg/g-8.11mg/g). Anti-nutrients of dried tiger nut were significantly reduced among other drying methods when compared with the control; anti-nutrient of the fresh and dried tiger nut range from Hydrogen cyanide (HCN) (0.012mg/g-0.401mg/g), Oxalate (0.016mg/g-0.084mg/g). Phytate (0.022mg/g-0.062mg/g), Tannin (Ta) (0.029mg/-0.0364mg/g). Anti-oxidant of the fresh and dried tiger nut ranged from 1, 1-diphenyl-2-picryllydrazyl (DPPH) (0.577%-2.23%), Cupric ion reducing capacity assay (CUPRAC) (0.52%-0.44%), Ferric ion reducing anti-oxidant power assay (FRAP) (0.40%-0.68%). At the end of this study, Oven drying maintained high nutritional content among the drying methods. Microwave oven drying method had the highest retention of its mineral composition when compared with the control. Sun drying had the lowest anti-nutrient among the drying methods. Microwave oven drying was effective in its anti-oxidant activity with reference to the control.

The Effect of Drying Methods on the Quality of Tiger nut *(Cyperus esculentus lativum)*

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ABSTRACT

This project aimed at evaluating the effect of different drying methods on the quality of tiger nut (*cyperus esculentum lativum*). Three drying methods: sun drying, oven drying and microwave-oven drying were employed. Analysis of proximate, minerals, anti-nutrient and anti-oxidant composition of fresh (control) and dried tiger nut were carried out using the official method of analysis by the association of analytical chemist (AOAC, 2010). Fresh tiger nut tubers were divided into four portions. Three of the four portions were dried to constant weights using sun, oven and micro-wave drying methods respectively. The fourth portion of the sample was not dried but serves as the control. result showed that the proximate composition of fresh and dried tiger nut sample for Moisture content ranged from (5-45%), Protein (1.04-3.50%), Ash (0.05-0.51%), fibre (3.69-5.04%). fat (23.48-24.11%). for the dried samples, microwave oven drying had the lowest moisture (5.0%), oven had the highest fibre (3.80%), oven had the highest ash (0.48%), oven had the highest fat (24.11%), and oven had the highest protein (3.50%) contents. These values were significantly different from ($p<0.05$) the control. The minerals composition of the fresh and dried tiger nut ranged from calcium (1.97mg/g-2.41mg/g), Potassium (2.29mg/g-3,83mg/g), Magnesium (1.03mg/g-5.33mg/g), and Zinc (5.09mg/g-8.11mg/g). Anti-nutrients of dried tiger nut were significantly reduced among other drying methods when compared with the control; anti-nutrient of the fresh and dried tiger nut range from hydrogen cyanide (HCN) (0.012mg/g-0.401mg/g), oxalate (0.016mg/g-0.084mg/g). Phytate (0.022mg/g-0.062mg/g), Tannin (Ta) (0.029mg/-0.0364mg/g). anti-oxidant of the fresh and dried tiger nut ranged from 1, 1-diphenyl-2-picryllydrazyl (DPPH) (0.577%-2.23%), Cupric ion reducing capacity assay (CUPRAC) (0.52%-0.44%), Ferric ion reducing anti-oxidant power assay (FRAP) (0.40%-0.68%). At the end of this study, oven drying maintained high nutritional content among the drying methods. Microwave oven drying method had the highest retention of its mineral composition when compared with the control. Sun drying had the lowest anti-nutrient among the drying methods. Microwave oven drying was effective in its anti-oxidant activity with reference to the control.

Keywords: Drying, Tiger nuts, Sun drying, Oven drying, Microwave drying, Drying rates, Drying methods

1. INTRODUCTION

Tiger nut "*Cyperus esculentus lativum*" is an underutilized tuber of family Cyperaceae, it produces rhizomes from the base of the tuber that is spherical (Devries and Feuke, 1999). It is a tuber that grows freely and is consumed widely in Nigeria and other parts of West Africa.
Tiger nuts exist in varieties (black, brown and yellow which are cultivated. Among these, the yellow variety is preferred over others because of its inherent properties such as large size, attractive color and fleshier nature. It yield more milk upon extraction, contains lower fat and higher protein (Okafor and Okolo, 2003). Tiger nut tubers appear long or round in shape with a dimension of 8mm to 16mm, the smaller size however, are not used for human consumption. Recently, there is awareness for increased consumption of tiger nut (Belewu and Abodunrin, 2006; Belewu, 2007). When hydrated, it is slightly harder (nut texture), but with a rather more intense and concentrated taste. The cultivation time is April to November.

Tiger nut, a tuber with sweet and nutty taste can be consumed raw, roasted, dried or as tiger nut milk or oil (Rita,2009) .It can be stored and rehydrated by soaking without losing the crop texture

which ensures acceptable sensory quality (Tucson, 2003). Drying of agricultural products helps to reduce the moisture content to a level that halts or control microbial growth and to reduce deteriorative chemical reaction in order to extend the shelf life of food (Mujumdar and Law, 2010).

In most agricultural based economies like Nigeria, large quantities of food products are dried to improve shelf life, reduce packaging costs, lower weights, enhance appearance, retain original flavor and most importantly maintain nutritional quality (Baysal *et al*., 2003; Demir *et al*., 2007; Simal *et al*., 2000; Ertekin and Yaldiz, 2004).

Sun, oven and microwave oven drying are common drying methods for agricultural crops. These drying methods have been reported to affect the nutrient composition of food in various ways. It can either increase the concentration of some nutrients by making them more available or decrease the concentration of some nutrients (Hassan *et al*., 2007; Morris *et al*., 2004; Ladan *et al*., 1997). Therefore, this project seeks to investigate the effect of different drying methods like sun drying, oven drying, and microwave oven drying on the quality of tiger nuts.

2. MATERIALS AND METHODS

SAMPLES COLLECTION AND PREPARATIONS

Fresh Tiger nuts were purchased from Itam Main Market, Uyo. Akwa Ibom State, Nigeria. The tubers were thoroughly screened to remove the bad ones and stones. They were washed, air dried and divided into four portions. Three of the four portions were dried to constant weight using sun, oven and micro-wave drying methods respectively. The fourth portion was not dried but was used as fresh sample which served as the control

Control: Hundred grammes of fresh tiger nut sample were kept as the control to be compared with the dried tiger nut samples.
Sun Drying: Hundred grammes of the samples were kept in the sun between 10:30 am to 3:30 pm daily and were dried to constant weight (22.690 g) for 60 hours.
Oven Drying: Hundred grammes of the samples was also placed in an electric oven and dried to constant weight (27.328 g) at 65°C for 20 hours.
Microwave Oven Drying: Hundred grammes of the samples were dried using a microwave oven to constant weight (28.120 g) for at 50°C for 15 minutes.

2.1 Materials and Equipment

For a successful execution of this research work, Sulphuric acid (H_2SO_4), copper sulphate ($CUSO_4$), sodium sulphate (Na_2SO_4), boric acid (H_3BO_3), hexane (C_6H_{14}), sodium hydroxide (NaOH) would be used in carrying out the proximate analysis of the samples.
Equipment to be used include: Kjeldahl (soxhlet) apparatus, water bath, electric oven (model PVHB-90G2HA), fume cupboard, desiccators, crucibles, Buckner funnel, measuring scale, muffle furnace (by Uhlg, Kern, U.S.A), sifter, JENWAY 6100 Spectrophotometer, Pearson Gallenkamp Flame analyzer, Buch Model 205 Atomic Absorption Spectrophotometer, electric oven, micro wave oven (Westpoint Microwave oven dryer), Digital thermometer, Weighing Balance, conical flask (250ml), volumetric flask, reflux device, acid burette, filtration device etc were used in this study.

2.2 Proximate Analysis of Tiger Nuts

The proximate components of the fresh, dried tubers of tiger nuts were using the standard methods of Analysis of Association of Official Chemists (AOAC), 2010. Crude protein, crude lipid, carbohydrate, Moisture, and Ash contents in the samples was analyzed. The methods are described below. The same procedures were carried out on all samples.

2.3 Mineral Content Analyses of Tiger Nuts

The minerals to be analysed would be Potassium, Calcium, Magnesium and Zinc. Potassium would be determined using Gallenkamp Flame analyzer, while calcium, magnesium and zinc would be determined using the atomic absorption spectrophotometer (model Unicam 900, Buck Scientific).
The digest solutions of the samples were prepared by weighing 1 grams of each of the powdered plant samples, these were digested with aqua regia at 130ºC using electric hotplate for 30 minute .the

filtered was made up to 100ml after filtration using 100ml volumetric flask. Standard solutions of the metal to be analyzed were prepared. The atomic absorption spectrophotometer (model Unicam 900, Buck Scientific) was set with power on for ten minutes. The standard minerals solutions were injected to calibrate the AAS using acetylene gas. An aliquot of ash solutions were injected and the concentrations obtained from the AAS.

Two grammes (2 g) of each tiger nut sample would be heated gently over a Bunsen burner flame until most of the organic matter was destroyed. This will be further heated strongly in a muffle furnace for several hours until white- grey ash was obtained. The ash material was cooled. About 20 ml of distilled water and 10 ml of the dilute hydrochloric acid was added to the ashen material. This mixture would be boiled, filtered into a 250 ml volumetric flask, washed thoroughly with hot water, cooled and made up to volume.

2.4 Anti-nutrients Analysis

2.4.1 Hydrogen Cyanide

Extraction of hydrogen cyanide was done using Wang and filled method. The sample (2g) was ground into paste and dissolved in distilled water (50ml) using a conical corked flask. The extract was allowed to stay overnight and the filtered solution was used for the cyanide determination. Alkaline picrate 4ml was added to 1m of the filtrate in a corked test tube and incubated in water bath for 15minutes. Reddish colour developed and the absorbance was taken using a spectrometer at 490nm (AOAC, 1984). Also, the absorbance of the blank containing only 1ml distilled water and 4ml alkaline picrate solution was taken and the extrapolation of the cyanide content from the cyanide standard curve.

Concentration of hydrogen cyanide is thus as follows;

$$\frac{absorbance\ test\ x\ conc.standard}{absorbance\ of\ standard\ x\ weight\ of\ sample} x \frac{100}{1} \quad (1)$$

2.4.2 Determination of Oxalate by Titration Method

The oxalate content of the sample was determined using titration method. It involves three general steps which include digestion, precipitation and $KMnO_4$ titration.

Digestion: 5g of the sample was introduced into a 250ml beaker suspended in 95ml of distilled water and 5ml 6N HCl was added to the beaker. The mixture was heated on a water bath at 50^0C for 2 hours. The digestion was filtered and diluted with distilled water to 126ml.

Precipitation: 50ml of the filtrate was placed in a 100ml beaker and drops of methyl red indicator was added which evaporated on eating to 250ml in volume. The sample was filtered to remove the precipitate containing ferrous irons. The filtrates were again treated with 5ml NH_4OH and heated to 90^0C and 10mn of 5% CaCl solution was added and stirred constantly as heat was applied and allowed to cool overnight at 5^0C. The solution was then centrifuged (filtered) at 2500rpm for 5 minutes. The supernatant was decanted and he precipitate were obtained which was washed into a beaker with H_2SO_4 (10ml of 20% v/v) and diluted with 125ml of distilled water.

Titration: the 125ml aliquot solution was heated near boiling point (90^0C) and was titrated against 0.05N standardized $KMnO_4$ solution to a faint pink color which persists for 10seconds.

The calcium oxalate content is calculated using the formular 0.05N $KMnO_4$ = 2.2g Oxalate.

2.4.3 Determination of Phytate

The phytate content of the tiger nut was determined by Maga method. Two (2g) grammes each finely ground flour sample was soak in 20ml of 0.2N HCl and filtered. After filtration, 0.5ml of the filtrate was mixed with 1ml ferric ammonium sulphate solution in a test tube, boiled for 30min in a water bath, cooled in ice for 15minute and centrifuged at 3000× g for 15 minutes. One millitre of the supernatant was mixed with 1.5ml of 2,2-pyridine solution and the absorbance measured in a spectrophotometer at 519nm. The concentration of phytic acid was obtained by extrapolation from a standard curve using standard phytic acid solution.

2.4.4 Determination of Tannin Content

For Tannin determination, 10ml 70% aqueous acetone was added to 2g of finely ground sample in a bottle and properly covered. The bottle was put in an ice bath shaker for 2h at 30oC. The solution was then centrifuged and the supernatant stored in ice. From the supernatant, 0.2ml was pipette into 0.8ml of distilled water. Standard tannic acid solution was prepared. Folin reagent (0.5ml) was added to both sample and standard followed by 2.5ml 20% Na_2CO_3. The solution was vortexed and allowed to incubate for 40minute at room temperature after which the absorbance was read at 725nm. The concentration of tannin in the sample was estimated from the standard tannic acid curve.

2.5 Antioxidants Analysis

2.5.1 DPPH Radical Scavenging Assay: The free radical scavenging capacity of the extracts from different plant samples were estimated according to Baraca, 2003 with slight modification using the stable 1,1-diphenyl-2-piccryllydrazyl (DPPH) radical which has an absorption maximum at 515nm. A solution of the radical is prepared by dissolving 2.4mg DPPH in 100ml methanol. A test solution100-500Nl was added to 3.95ml (4ml) of methanolic DPPH. The mixture was shaken vigorously and kept at room temperature for 30min in the dark. Absorbance of the reaction mixture was measured at 515nm spectrophotometric absorbance of the DPPH radical without antioxidant i.e. blank was also measured. All the determinations were performed in duplicates. The capacity to scavenge the DPPH radical was calculated using the following equation:

$$\text{DPPH Scavenged (\%)} = \frac{(AB - AA)}{AB * 100} \quad (2)$$

Where AB = Absorbance of Blank

AA is absorbance of the antioxidant at t = 30minutes

2.5.2 Ferric Ion Reducing Antioxidant Power Assay (Frap)

Ferric ion reducing power was measured according to the method of Oyaizu with a slightest modification.

Procedure: Hydroalcoholic extract of the sample in different concentration ranging from 100nl to 500nl were mixed with a 2.5mM phosphate buffer and 2.5ml, 1%, w/v potassium ferric cyanide, and then the mixture was I incubated at 50*c for 30minutes. Afterward, 2.5ml of 10%, w/v trichloroacetic acid and 0.5ml 0.1%, w/v ferric chloride were added to the mixture, which was kept aside for 10min. finally, the absorbance was measured at 700nm. Ascorbic acid was used as positive reference standard. All assays were run in duplicates and averaged.

2.5.3 Cupric Ion Reducing Capacity Assay (Cuprac)

Cupric ion reducing capacity was measured in accordance to the method of Apal.

Procedure

1ml, 10mM cupric chloride, 1ml 7.5mM neocuproine and 1ml, 1M ammonium acetatate buffer of PH 7 solutions were to test tubes containing 2ml of distilled water. Hydroalcoholic extract of the sample in different concentration ranging from 100nl to 500nl were added to each test tube separately. These mixtures were incubated for half an hour at room temperature and measured against blank at 450nm. Ascorbic acid was used as positive reference standard. All methods were repeated in duplicates in order to get a mean value.

2.6 Statistical Analysis

The experiments were conducted in duplicates. The mean and standard deviation of the result data from the experiment will be calculated and analyze using single factor ANOVA in the Statistical Package for Social Science (SPSS, 2017) Software (SPSS version 20 for windows). The Duncan's New Multiple Range Test (DNMRT) and Ordinary Least Significant Difference (LSD) were also used to determine the significant difference between mean values (Spiegiel *et al*., 2008).

3. RESULTS AND DISCUSSIONS

3.1 Drying Rate Curve

Below are the drying rate curves showing different drying methods with different drying rates. Figure 4.1 shows the drying rate curve for sun drying. Here, there was a rapid increase in drying rate from 0 - 14.44 gH_2O/hr between 0-5 hours. A rapid decrease in drying rate from14.44 - 0.177gH_2O/hr between 5 - 45 hours of drying time, and a minimum of 0.114 gH_2O/hr constant drying rate was found between 45-60 hours of drying time. Figure 4.2 shows the drying rate curve for oven drying. Here, there was a rapid increase in drying rate from 0-1 hour with a maximum corresponding drying rate of 66.311gH_2O/hr. Between 1-12 hours of drying time, there was a rapid decrease in drying rate from 66.311 - 0.851gH_2O/hr and between 12-20 hours of drying, the drying rate decreased from 0.851 gH_2O/hr to a constant value of 0.237 gH_2O/hr. Figure 4.3 shows the drying rate curve for microwave oven drying. Here, there was a rapid increase in drying rate from 0 - 11.058 gH_2O/min between 0-5 minutes and decreased from 11.058 - 0.662gH_2O/min between 5-15 minutes of drying time. Different drying methods had varying energy output and usage and these had different impact on the samples; and also affect the quality of product differently. Generally, the drying rate decreased as the drying time increased. For sun drying, the drying rate was low and it took about 60 hours to dry to a bone dry weight of 22.690 grams. For oven drying, the drying rate was faster compared with the sun drying, and it took about 20 hours to dry to a bone dry weight of 27.328 grams. Microwave oven had the highest drying rate, which took about 15 minutes to dry to a bone dry weight of 28.120 grams. Microwave oven had the highest drying rate among other drying methods.

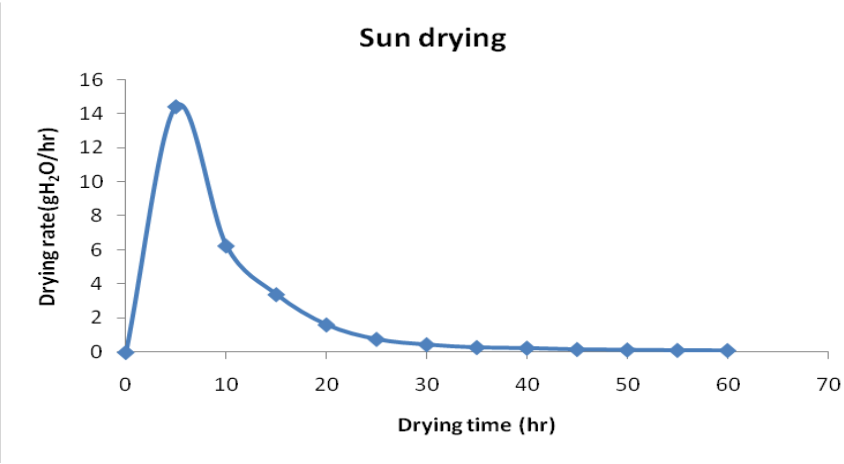

Figure 3.1: Drying rate curve for sun drying.

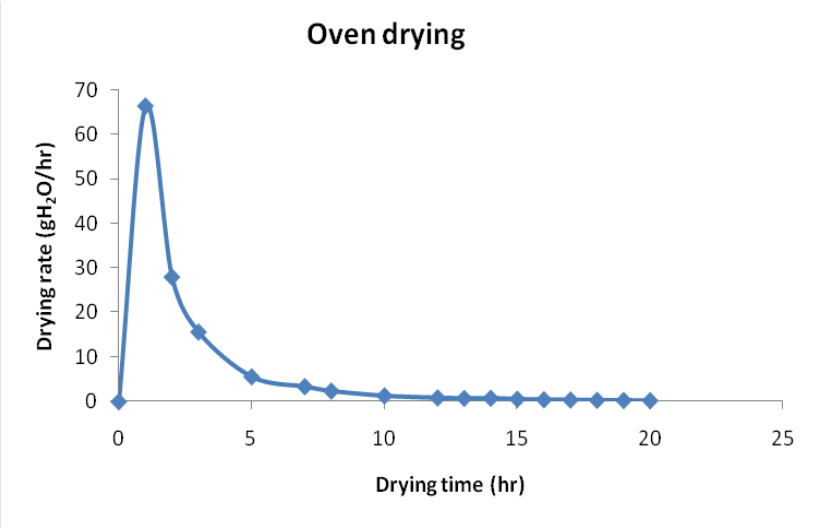

Figure 3.2: Drying rate curve for Oven drying.

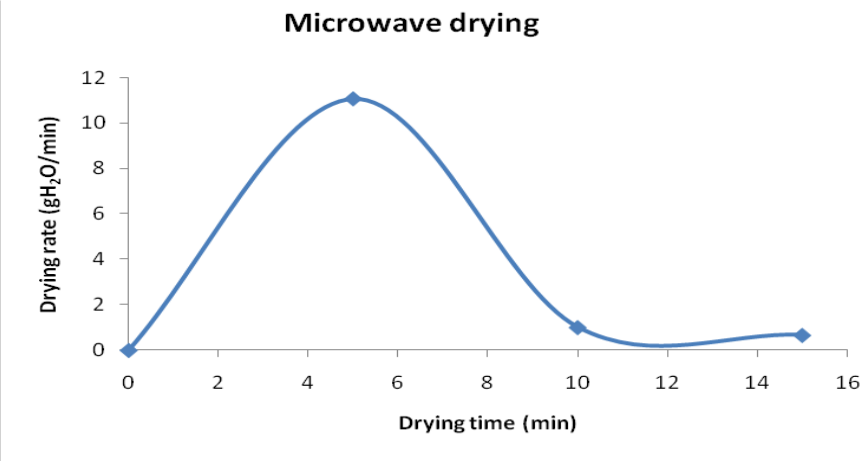

Figure 3.3: Drying rate curve for Microwave oven drying.

3.2 Effect of drying methods on the proximate compositions of tiger nut

Table 3.2A: Effect of different drying methods on proximate composition of tiger nut

Drying Method	Moisture Content (%)	Crude Fibre (%)	Ash Content	Crude Lipid
Fresh	45.0050 ± 0.00707*	5.0495 ± 0.07000*	0.5105 ± 0.00071*	23.4830±0.00141*
Microwave	5.0005 ± 0.0071*	3.6985 ± 0.00071b	0.0495 ± 0.00071P	24.1075±0.00071*
Oven	10.0050 ± 0.00707a	3.8050 ± 0.00707*	0.4805 ± 0.00071*	24.1150±0.00424*
Sun	10.0010 ± 0.00141a	3.6910 ± 0.00141b	.0505±0.00071P	24.0340±0.00141*

Values are means ± standard deviation from duplicate analyses
Values with asterisk (*) showed significance difference in their mean at 5 % level. Values with same alphabet in the same column did not differ in their mean at 5% level of significance.

Table 3.2B: Effect of different drying methods on proximate composition of tiger nut

Drying Method	Crude protein	Total Carbohydrate (%)	Caloric value (Kcal)
Fresh	1.7600± 0.01414*	69.1965 ± 0.08697*	495.1750± 0.27577*
Microwave	1.7005±1.7005*	70.4435 ± 0.00212*	505.5455±0.00354h
Oven	3.5035 ± 0.00495*	70.0955 ± 0.00778*	503.4310 ± 0.04950*
Sun	1.0400 ± 0.01414*	71.1835 ± 0.01020*	505.2000 ± 0.00424h

Values are means ± standard deviation from duplicate analyses
Values with asterisk (*) showed significance difference in their mean at 5 % level of significance. Values with same alphabet in the same column did not differ in their mean

Tables 3.2A and B present the effect of different drying methods on the proximate composition of fresh and dried tiger nuts per 100 grams. The moisture content of tiger nut ranged from 45% in the fresh sample (control) to 5.0% in the microwave oven; only oven and sun drying methods did not produce significant difference in their mean values, since p [0.474] > 0.05. Reduction in the moisture content as observed in this study decreases the perishability of tiger nut, adds value and also extends the shelf life, thereby making it available throughout the year, similar to the report of Demirel and Turhan (2003) and Emperatriz *et al.* (2008**)** .The tiger nut samples were samples were significantly different ($p<0.05$) in fibre content except for microwave and sun drying methods which did not produce significant difference in their mean values of fibre content since p [0.842] > 0.05. The fresh tiger nut sample had higher (5.04%) fibre content than the dried samples as compared with (Okorie and Nwanekezi, 2014).The reduction observed in the dried sample might be due to the fact that drying softens cellulose, and encourage loss of indigestible plant components, causing the cells to separate easily and making the nut easier to digest (Cameron, 1983). Loss of soluble fibre by hydrolysis, enzymatic degradation and decomposition caused fibre to reduce (Morris *et al.,* 2004). Ash content was highest in the fresh sample (0.51%) and it was lowest in the microwave dried tiger nut (0.04%) but only microwave and sun drying methods did not produce significant difference in their mean values, since p [0.230] > 0.05, this is as a result of their moisture content and leaching of it minerals during drying as reported by Ogunlade *et al.* (2015). There was a significant increase in lipid content as fresh sample had the lowest lipid content (23.4%) but highest in the oven dried sample (24.1%). Increased in the lipid content of dried tiger nuts is attributed to concentration of fat due to moisture loss (Ndubuisi, 2009). Protein content decreases significantly when compared with the fresh sample, this is in line with the report by Miroslawaet *et al.*(1997) that heat application caused the unzipping of the hydrophobic force leading to partial or complete disruption of the primary, secondary tertiary or quaternary structure of protein molecules thereby leading to the protein content of the dried sample. Crude protein was lowest in the sun dried sample (1.04%) when compared with that of the fresh sample (1.76%). There was an increased in the carbohydrate contents when compared with the fresh sample (69.19%), this may be attributed to moisture loss which leads to concentration of nutrient (Ndubuisi, 2009); Total carbohydrates were highest in the sun dried tiger nuts (71.1%) but lowest in the oven dried samples (70.09%). Caloric value increased significantly among the drying methods with reference to the control. Microwave dried tiger nut had the highest caloric value (505.5 KJ) and lowest in the fresh sample (495.17%) ; Only microwave and sun drying methods did not produce significant difference their mean values since their p [0.069] > 0.05.

3.3 Effect of Drying Methods on the Minerals Composition of Tiger Nut

Table 3.3: Mineral composition of fresh and dried tiger nuts (mg/100g)

Treatment		Calcium	Potassium	Magnesium	Zinc
	Fresh	2.4150±0.00141*	3.8305±0.0071*	5.3305±0.7566*	8.1165±0.0071*
	Microwave	2.0845±0.00071a	2.3050±0.00141*	2.0320±0.141*	6.0080±0.00141*
	Oven	2.0845±0.00071a	2.2960±0.00141b	1.2090±0.000*	5.1210±0.00141*
	Sun	1.9740±0.00141*	2.2960±0.00141b	1.0375±0.00071*	5.0920±0.00141*

Values are means ± standard deviation from duplicate analyses
Values with asterisk (*) showed significance difference in their mean at 5 % level of significance. Values with same alphabet in the same column did not differ in their mean

Table 3.3 present the effect of different drying methods on the mineral composition of tiger nuts. The minerals composition of the dried tiger nuts was reduced when compared with the fresh sample. The fresh sample indicates high calcium content (2.41mg) but lowest in sun dried sample (1.97mg) when compared with the other drying methods. Calcium content of the micro wave oven and the oven dried tiger nut were not significantly different with their means at 5% level of significance. Potassium content was highest in the fresh sample (3.83mg) but lowest in oven and sun dried tiger nuts (2.29mg) which were not significantly different with their mean. There was a significant difference among Magnesium content of tiger nuts with its content highest in the fresh sample (5.33mg) but lowest in the sun dried samples (1.03mg). Fresh tiger nut had the highest Zinc composition (8.11mg) but lowest in the sun dried tiger nuts (5.09mg).The decrease in the mineral content of tiger nuts after drying, suggest that the presence of anti-nutritional factors such as oxalate and phytate in this tuber made these minerals unavailable by reacting with them, this is similar to the report of Akpan and Umoh (2004). Microwave oven drying had the highest mineral retention when compared with other drying methods with reference to the control sample.

3.4 Effects of drying methods on the anti nutrient composition of tiger nuts

Table 3.4 Anti nutrient composition of fresh and dried tiger nuts (mg/100g)

Treatment		HCN	Oxalate	Phytate	Tannin
	Fresh	0.0122±0.00007*	0.084±0.00141*	0.0622±0.0014*	0.0292±0.0021*
	Microwav	0.0226±0.00078*	0.1410±0.00141*	0.0482±0.00141*	0.314±0.00014*
	Oven	0.0279±0.00007*	0.0435±0.00212*	0.0227±0.0028[a]	0.0358±0.000*
	Sun	0.4011±0.0007*	0.0160±0.00141*	0.0227±0.00028[a]	0.0364±0.00035*

Values with asterisk (*) show significance difference in their means at 5% level of significance.
Values with same alphabet in the same column did not differ in their mean.

Table 3.4 present the effects of drying methods on the anti nutrient composition of fresh and tiger nut. It shows that drying methods had a significant reducing effect on anti-nutrients compositions except for Hydrogen cyanide and Tannin. Reduction in anti-nutrient of the sample was observed mostly in sun dried sample; this is as a result of the evaporation of toxic chemicals from tiger nut samples during sun drying into the atmosphere. Oxalate content was reduce significantly when compared with the fresh sample, it was highest in the microwave sample (0.141mg) and lowest in the sun sample (0.016mg). Phytate was highest in the fresh sample (0.0622mg) and lowest in the oven and sun dried samples (0.0227mg); Hydrogen Cyanide content of the tiger nut were increase and significantly different with their means at 5% level of significance. It was lowest in the fresh sample (0.0122mg) and highest in the sun dried samples (0.4011mg). Tannin indicates a high content in micro wave oven sample (0.314mg) but low in the fresh sample (0.029mg).

3.5 EFFECT OF DRYING METHODS ON ANTI OXIDANTS OF FRESH AND DRIED TIGER NUTS

Table 3.5 Effect of drying methods on anti oxidants of fresh and dried tiger nuts (mg/100g)

Treatment		DPPH	Cuprac	FRAP
	Fresh	2.2315±0.00212*	0.0520±0.0000a	0.4040±0.00283*
	Microwave	1.0400±0.00141*	0.4450±0.0000*	0.6820±0.00141*
	Oven	0. 9710±0.00283*	0.2890±0.0000*	0.4065±0.00212*
	Sun	0.5775±0.0.00212*	0.0530±0.00141[a]	0.5880 ±0.00141*

Values with asterisk (*) show significance difference in their means
Values with same alphabet in the same column did not differ in their mean.

Table 3.5 highlights the effect of drying methods on the antioxidant activity of fresh and dried tiger nuts. Their antioxidant activity was significantly different at 0.05 significant level among their mean. DPPH was found to be highest in the fresh sample (2.23mg) but lowest in the sun dried tiger nuts (0.577mg). Cupric ion reducing capacity assay CUPRAC was highest in the microwave sample (0.445mg) but lowest in the fresh sample (0.052mg); only sun drying method and fresh did not produce significant difference their mean values since p [0.184] > 0.05.Ferric ion reducing antioxidant power assay (FRAP) was highest in the microwave sample (0.682mg) but lowest in the fresh sample (0.404mg). Microwave dried sample was highest in its anti-oxidants activity to neutralize the toxicity of anti-nutrients in tiger nuts.

4. CONCLUSION

Preservation of food by drying is a common practice in different parts of the world and it is used to extend the shelf life of food. Drying allows food to be preserved by removing the moisture in the food, in order to prevent the growth of microorganisms that cause deterioration (Mukhtar, 2009). It ensures their availability all year round, reduce post harvest losses and achieve food security. In this study, drying methods used includes: sun drying, oven drying and microwave oven used were capable of preserving the nutrients in the food crops without total loss of any nutrient. The following conclusions were deduced:

a. Oven and micro wave drying were observed to be more hygienic and faster than the sun drying. However, Micro wave drying had the highest drying rate than oven drying and it also gave the lowest **moisture content** in this study, suggesting a higher capacity to prevent microbial growth and decay in the dried samples, thus, confers a greater increase in shelf life on the dried samples.
b. There were decrease in fiber, ash and protein contents of dried samples, using all the drying methods whiles fat, carbohydrate and energy value were increased.
c. The drying methods had a reducing effect on the minerals composition of the dried tiger nuts when compared with the fresh sample, though microwave samples had the highest retentions among the other drying methods.
d. This study showed that drying method reduced the anti-nutrients in tiger nut (*Cyperus esculentus lativum) w*hen compared with the fresh sample.
e. There was a significant difference in the anti-oxidant activity of the tiger nut tubers. Cupric ion reducing capacity (CUPRAC) and ferric ion reducing antioxidant power (FRAP) increased with all the drying methods.
f. The drying time affected the anti-oxidant activity of the product
g. At the end of this study, it was observed that oven drying had the best nutritional composition, micro wave dried tiger nuts had the highest anti-oxidant activity and minerals composition. Sun drying had the lowest anti nutrient composition on tiger nutsas a result of decomposition of these anti nutrients into the soil and escape into the atmosphere during sun drying process.

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I appreciate my parents; Mr and Mrs. Ufot Gilbert for their unquantifiable love, support and guidance during this period. I wish to thank my wonderful siblings who provide unending support and inspiration.

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10:30 AM - 10:45 AM (Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room C)

[5-1015-C-02] Optimization and Storage Stability Evaluation of Antioxidant Extracts From Batangas Cherry (*Terminalia microcarpa* Decne)

*Dennis Marvin Opena Santiago[1], Shekayna Eunice Balmes Pacia[1], Jake Lloyd Cabrera Peña[1,2], Claire Solis Zubia[1], Sheba Mae Magbanua Duque[1] (1. Institute of Food Science and Technology, College of Agriculture and Food Science, University of the Philippines Los Banos, College, Laguna 4031 Philippines(Philippines), 2. Department of Science and Technology CALABARZON Region, Regional Science and Technology Center Complex, Jamboree Road, Timugan, Los Banos, Laguna 4030 Philippines(Philippines))

Keywords: Solvent extraction, Box-Behnken design, Batangas Cherry, DPPH scavenging activity, Anti-microbial activity

Effects of extraction parameters, including temperature, solvent to sample (S/S) ratio and ethanol concentration on % 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity were optimized using Box-Behnken design (BBD) of experiment. Moreover, effects of pH (3.5 to 9), and storage condition (5 and 25 ^{o}C) on the stability and antimicrobial activity of antioxidant extracts from Batangas Cherry were determined. Result showed that the optimum condition for extraction antioxidants from Batangas Cherry was at 80^{o}C, 10mL g^{-1} S/S and 51.66% ethanol. Batangas cherry extracts exposed at pH8 and 9 showed significant decrease in antioxidant and antimicrobial activities. On the other hand, storage at 5^{o}C better retained the antioxidant and antimicrobial activities of Batangas Cherry extracts. The baseline data in this research is important on maximizing the potential of Batangas as source of functional ingredient for food processing.

Oral Session | Postharvest/Food Technology and Process Engineering
[5-1015-C] Postharvest/Food Technology and Process Engineering (5)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room C (3rd room)

[5-1015-C-03] Effects of Pre-drying treatment and Drying-air Temperature on Moisture Ratio and Effective Moisture Diffusivity of Tomato (Nigerian Local and Foreign Varieties)

*Obafemi Ibitayo Obajemihi[1], Joshua Olanrewaju Olaoye[2], Mayowa Saheed Sanusi[1] (1. Food Engineering Department, University of Ilorin(Nigeria), 2. Agricultural and Biosystems Engineering, University of Ilorin(Nigeria))

Keywords: Hausa, Tiwantiwa, Honey and Sugar, Tomato

Tomato is a crop that is highly perishable and there are huge postharvest losses incurred annually in Nigeria. Drying of the fruit is important and suitable for developing economies. However, the heat employed during drying of tomato can influence its quality adversely, as a result it is important to use pre-drying treatments prior to drying operation. Therefore, the aim of this research was focussed on studying the effects of pre-drying treatment and drying-air temperature on moisture ratio (MR) and effective moisture diffusivity of tomato. Three varieties (Hausa, Tiwantiwa and Roma VFN) of fresh tomato were obtained from local farmers in Ilorin province, Kwara state of Nigeria. The samples were sorted and cleaned under running water, and were sliced at different thicknesses (5 mm, 7.5 mm and 10 mm), deseeded and blanched in hot distilled water at 90oC. The samples were further pre-treated using different chemical and osmotic solutions (2% ethyl acetate, 1% MgCl2 .6H_2O and 0.5% $Na_2S_2O_5$, 0.5% NaCl and 40oBx of honey and sugar) and Control (Non-pretreated). Samples were drained for 10 minutes after pre-drying treatment and were dried at different temperatures (45, 55 and 65oC) in an automated forced convection cabinet dryer (FCCD) instrumented for the purpose of this experiment. Weight loss of the samples were recorded at different intervals (15 - 60 min) on the trays per stage with the aid of a weight reduction sensing mechanism attached through the rear of the dryer. The drying process was stopped (through a computer system connected to the dryer) when the samples had reached their final moisture content <5% (db). The data obtained from the drying process were used to compute the samples moisture ratio and effective moisture diffusivity and were analyzed using regression and analysis of variance (ANOVA) with Design expert v. 6.0.6 statistical tool at $p < 0.05$. The results obtained show that samples lowest MR were obtained under these conditions; processed Hausa variety, 10 mm thickness, ethyl acetate pre-drying treatment and dried at 55oC while highest effective moisture diffusivity were obtained under these conditions processed Hausa variety, 5 mm thickness, honey and sugar pre-drying treatment and dried at 65oC in a FCCD. It was therefore concluded that processed Hausa variety was more preferable to other varieties used as it promotes low MR and high effective moisture diffusivity during the drying process. This will help reduce energy consumption associated with drying process.

Effects of Pre-drying Treatment and Drying-air Temperature on Moisture Ratio and Effective Moisture Diffusivity of Tomato (Nigerian Local and Foreign Varieties)

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ABSTRACT

Tomato is a crop that is highly perishable and there are huge postharvest losses incurred annually in Nigeria. Drying of the fruit is important and suitable for developing economies. However, the heat employed during drying of tomato can influence its quality adversely, as a result it is important to use pretreatments prior to drying operation. Therefore, the aim of this research was focused on studying the effects of pretreatment and drying-air temperature on moisture ratio (MR) and effective moisture diffusivity of tomato. Three varieties (*Hausa, Tiwantiwa* and Roma *VFN*) of fresh tomato were obtained from local farmers in Ilorin province, Kwara state of Nigeria, the samples were sorted and cleaned under running water, and were sliced at different thicknesses (5 mm, 7.5 mm and 10 mm), deseeded and blanched in hot distilled water at 90^{o}C. The samples were further pretreated using different chemical and osmotic solutions (2% Ethyl acetate, 1% $MgCl_2 \cdot 6H_2O$ and 0.5% $Na_2S_2O_5$, 0.5% NaCl and 40^{o}Bx of Honey and Sugar) and Control (Non-pretreated). Samples were drained for 10 minutes after pre-drying treatment and were dried at different temperatures (45, 55 and 65^{o}C) in an automated forced convection cabinet dryer (FCCD) designed for the purpose of this experiment. Moisture loss of the samples were recorded at different intervals (15 - 60 min) on the trays per stage with the aid of a weight loss sensing mechanism attached through the rear of the dryer. The drying process was stopped (through a computer system connected to the dryer) when the samples had reached their final moisture content < 5% (db). The data obtained from the drying process were used to compute the samples moisture ratio and effective moisture diffusivity and were analyzed using regression and analysis of variance (ANOVA) with Design Expert V 6.0.6 statistical tool at $p < 0.05$. The results obtained show that samples lowest MR were obtained under these conditions; processed *Hausa* variety, 10 mm thickness, Ethyl acetate pre-drying treatment and dried at 55^{o}C while highest effective moisture diffusivity were obtained under these conditions processed *Hausa* variety, 5 mm thickness, Honey and Sugar pre-drying treatment and dried at 65^{o}C in a FCCD. It was therefore concluded that processed *Hausa* variety is more preferable to other varieties used as it promotes low MR and high effective moisture diffusivity during the drying process. This will help reduce energy consumption associated with drying process.

Keywords: Honey and Sugar Hausa Tiwantiwa Slice thickness Tomato

1. INTRODUCTION

Tomato is one of the major vegetable crops cultivated in Nigeria and has been known to be highly perishable (Onifade et al., 2013; Idah and Obajemihi, 2014). Drying of fruits and vegetables such as tomato is gaining popularity in Nigeria, where post-harvest loss of farm produce is on increase on yearly basis, due to poor post-harvest handling techniques; as a result, Nigerians have spent a whooping sum of $1bn annually on imported tomato products (UNEP, 2016). Drying is a heat and mass transfer phenomenon and has saved more than 20% of crops that are perishable in the world; by extending their shelf lives and ensuring food security (Sohail et al., 2011). Drying is important and most times indispensable in the formulation of functional food products (Trivedi et al., 2011). Drying

of tomato products usually occur in the falling rate period as the moisture content tends to decrease with time.

It is important to study and understand mass transport mechanisms such as moisture ratio (MR) and effective moisture diffusivity (D_{eff}) responsible for drying of tomato and what to be done during pre-drying and drying processes to favour them. Moisture ratio is the ratio of the instantaneous moisture content to that of the fruit's initial moisture content. Effective moisture diffusivity is an internal transport phenomena and it is the rate at which moisture is moved from the center of the fruit to its surface where it will be evaporated (Onwude et al., 2016). D_{eff} is a function of drying-air temperature and samples' MR and was seen as an important mass transport mechanism when it comes to studying drying processes involving fruit and vegetable (Onwude et al., 2016). Zogzas et al. (1996), stated that increase in temperature brings about increase in effective diffusivity but changes with respect to moisture content. When the temperature of food is high, the water molecules in it are bounded loosely to food matrix than at low temperature, therefore more energy is required to remove moisture at lower temperatures compared with high temperatures. Also food structure and void fraction present can significantly affect moisture diffusivity and hence reported that at low porosity, value of effective diffusivity of moisture is majorly by liquid diffusion which is different from that obtainable for granular or porous material, moisture movement is mainly by vapour diffusion through the void or empty spaces. D_{eff} and velocity of moisture movement within the material are relatively related while drying rate is the rate at which moisture vaporizes to the surrounding air or a change of moisture to vapour by evaporation which depends largely on the pressure difference existing between the food material and surrounding air as a result of temperature difference (So'bah et al., 2017).

Pre-drying treatment of fruits and vegetables has been known to favour or disfavour their drying rates which is a function of both internal mass transport mechanisms and external heat (Mauro et al., 2005). It helps retain food sensory and nutritional qualities; as previous researches have shown that the effects of drying-air conditions, most especially drying-air temperature have adversely affected the quality attributes of tomato if not properly controlled.

Therefore, it becomes imperative to investigate the effects of pre-drying treatment and drying-air temperature on moisture ratio and effective moisture diffusivity of tomato.

2. MATERIALS AND METHODS

2.1 Raw Material

Fresh tomato samples of three different varieties were obtained from local growers in Oteh area, a surburb of Ilorin Kwara State of Nigeria. The samples were sorted visually according to their ripeness, firmness and size. Samples were thoroughly washed under tap water, sliced using a stainless steel knife, deseeded with a needle and blanched in hot water for 1 min at 90^{o}C to minimize browning and enzymatic reaction during drying process.

2.2 Pre-drying treatment Process

Sliced samples were divided into five parts and were subjected to further pre-drying treatments following the mechanical and thermal pre-drying treatments used on them initially. These other methods include treatment in osmotic and chemical solutions. The first, second, third and fourth parts were treated in a mixture of honey and sugar solution at 40^{o}Bx concentration (honey: sugar: water ratio 2: 1: 1.9) for 10 min which was prepared using a refractometer (Model: M10481, by ABBE MARK II, USA), 2% ethyl acetate solution for 1 min, 0.5g/100ml NaCl solution for 10 min and 1% $MgCl_2 \cdot 6H_2O$ and 0.5% $Na_2S_2O_5$ for 10 min respectively. And the fifth part served as the control sample which was immersed in distilled water at room temperature for 10 min. Each sample weighed 250 g with an electronic balance (Model: WH-B06, sensitivity ± 0.01g by WEIHENG, China) before pre-drying treatment. After pre-drying treatment samples were drained and bloated with absorbent paper.

2.3 Drying Procedure

After pre-drying treatments of the samples they were dried in an automated forced convection cabinet dryer (FCCD) designed for the purpose of this research at different drying-air temperatures (45, 55 and 65^{o}C), the dryer was run to attain the desired temperature before loading the samples on its labelled

trays. The trays were rested on load cells which were linked to a microcontroller which was in turn connected to a computer system which has a software with Arduino programme used in monitoring and controlling the dryer. The dryer was also equipped with a thermo-hygrometer sensor used in sensing the drying-air temperature and humidity and three (3) solid state relays which were used for switching on and off the two (2) heaters (3.6 kW) and a centrifugal fan (2m/s). The dryer was pre-selected to take record of every 5 min as the drying experiment progressed. The measurements recorded were the instantaneous weight on each of the four (4) trays, the drying-air temperature and humidity. This dryer totally eliminates the drudgery, time and energy wastages associated with previous drying experiments when samples were brought out to measure. The FCCD is shown in Figure 1.

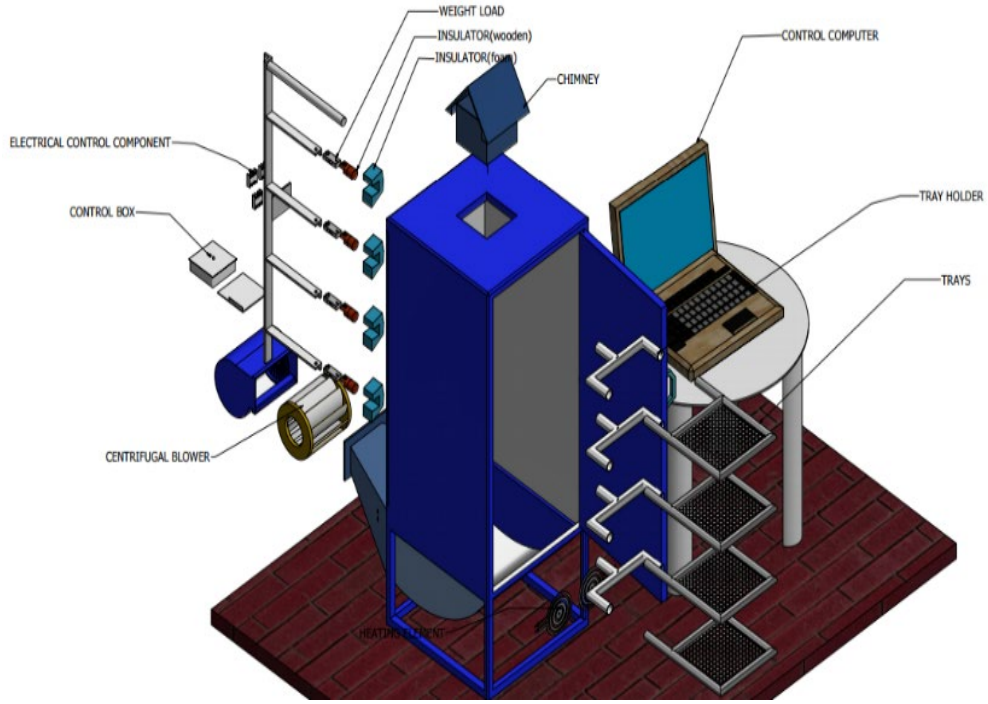

Figure 1. 3D View of the Automated FCCD

2.4 Determination of output Parameters

2.4.1 Instantaneous Moisture Content (M_t)

The instantaneous moisture content (M_t) of tomato at any given time (t) during the drying experiment was estimated using Equation 1;

$$M_t = \frac{(M_o + 1) - W_t - 1}{W_o} \quad (1)$$

where;

M_t = Instantaneous m.c. (% wb)

M_o = Initial m. c. (% wb)

W_t = Weight of product at any time, t during drying (g)

W_o = Initial weight of the sample (g)

2.4.2 Moisture Ratio (MR)

Moisture ratio was calculated as expressed in Equation 2;

$$MR = \frac{M_t - M_e}{M_o - M_e} \quad (2)$$

where;
M_t = m.c. of the tomato samples at any time t (% db)
M_e = Equilibrum m.c. of the tomato samples (% db)
M_o = Initial m.c. of the samples before drying (% db)

2.4.3 Effective Moisture Diffusivity

The effective moisture diffusivity (D_{eff}) was estimated using the "simplified mathematical Fick's second diffusion model". The solution of Fick's second law in slab geometry, having the following assumptions; that moisture migration is strictly dependent on diffusion, shrinkage is negligible, diffusion coefficients are constant and temperature which was the diffusion model was simplified to linear equation by Crank (1975) as it is expressed in Equation 3.

$$MR = \frac{M}{M_0} = \frac{8}{\pi^2}\sum_{n-1}^{\infty}\frac{1}{(2n-1)^2}\exp\left[\frac{(2n-1)^2\pi^2 D_t}{4L^2}\right] \quad (3)$$

where,
MR = Moisture Ratio
M = Moisture content at any time (kg water/kg dry matter)
M_o = Initial moisture content (kg water/kg dry matter)
n = 1,2,3,... the number of terms taken into consideration
t = time of drying in seconds
D_t = Effective moisture diffusivity (m^2/s)
L = thickness of the slice (m)

Equation 4 was used since the drying process involved a long term drying due to high moisture content present in tomato

$$MR = \frac{8}{\pi^2}\exp\left[\frac{\pi^2 D_t}{4L^2}\right] \quad (4)$$

The slope (K_o) of the graph was estimated by plotting *ln (*MR) against time (t) as presented in Equation 5;

$$K_o = \frac{\pi^2 D}{4L^2} \quad (5)$$

2.5 Design of Experiment

The experiment was designed using the Box-behnken design (BBD) of response surface framework of Design Expert Software V 6.0.6 (US, Stat-Ease Inc.) resulting in 68 runs. The experimental input parameters were sample variety (*Hausa, Tiwantiwa* and Roma *VFN*), slice thickness (5.0 mm, 7.5 mm and 10 mm), pre-drying treatment (Ethyl acetate, $MgCl_2{\cdot}6H_2O$ and $Na_2S_2O_5$, NaCl and Honey and Sugar) and drying-air temperature (45, 55 and 65°C).

2.56 Statistical Analysis

In this experiment statistical analysis of responses were done using quadratic model interface of the Design Expert software with alpha to exit 0.050 and regression coefficients were obtained.

3. RESULTS AND DISCUSSION

3.1Effects of Input Parameters on Moisture Ratio and Effective Moisture Diffusivity

3.1.1 Effect of Drying-air Temperature, Slice Thickness, Variety and Pre-drying Treatments on Moisture Ratio

The effect of drying-air temperature on the moisture ratio (MR) of tomato samples is shown in Figure 2 a, it shows that samples subjected to 65ºC had average MR of 70.19%, 55ºC had 69.13%, while those subjected to 45ºC had the highest average MR of 77.54%. This result agrees with the findings of Yousefi et al. (2013) on the drying of papaya slices at 40, 50 and 60ºC. The highest MR in samples dried at 45ºC can be attributed to the slowest rate at which

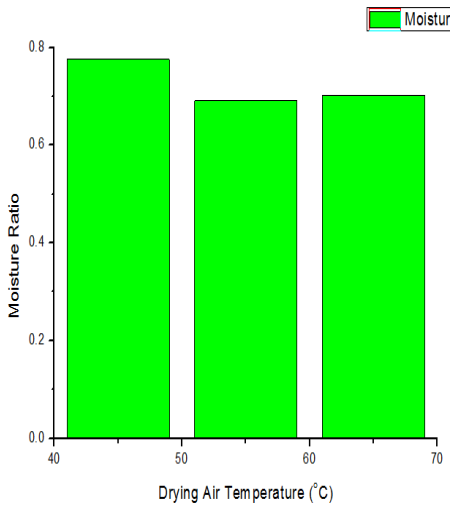

Figure 2 a: Effect of Air-temp. on Moisture Ratio

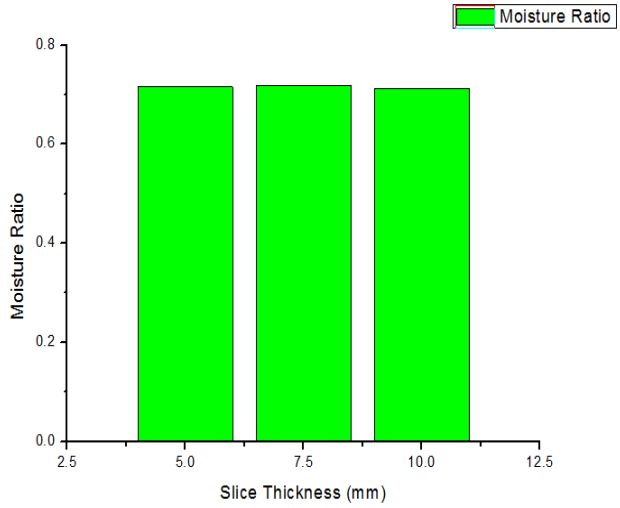

Figure 2 b: Effect of Slice Thickness on Moisture Ratio

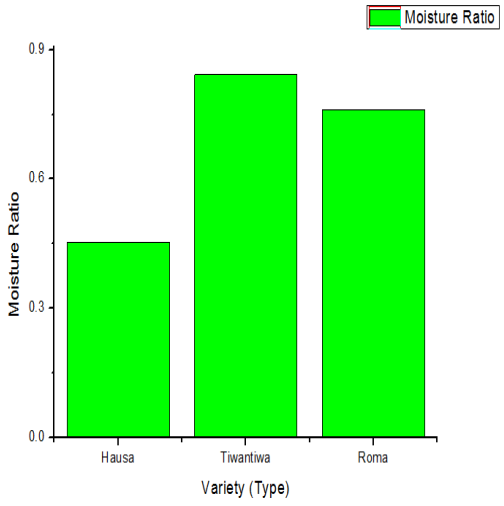

Figure 2 c: Effect of Variety on Moisture Ratio

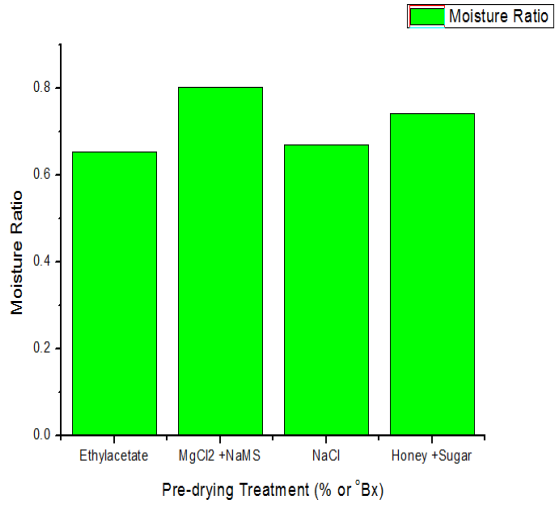

Figure 2 d: Effect of Pre-drying Treatment on Moisture Ratio

Table 1: Analysis of Variance for Moisture Ratio of Tomato Slices

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	2.32	21	0.11	11.95	< 0.0001	*Sig.*
A	0.061	1	0.061	6.60	0.0137	
B	2.979E-005	1	2.979E-005	3.217E-003	0.9550	
C	0.90	1	0.90	97.05	< 0.0001	
D	0.21	3	0.071	7.63	0.0003	
A^2	9.739E-003	1	9.739E-003	1.05	0.3107	
B^2	2.642E-003	1	2.642E-003	0.29	0.5959	
C^2	0.93	1	0.93	100.38	< 0.0001	
AB	3.169E-004	1	3.169E-004	0.034	0.8541	
AC	0.034	1	0.034	3.69	0.0611	
AD	0.057	3	0.019	2.07	0.1184	
BC	5.621E-003	1	5.621E-003	0.61	0.4401	
BD	6.219E-003	3	2.073E-003	0.22	0.8793	
CD	0.11	3	0.035	3.83	0.0160	
Residual	0.41	44	9.260E-003			
LOF	0.40	28	0.014	25.55	0.0001	
Pure Error	8.914E-003	16	5.571E-004			
Cor Total	2.73	65				

LOF-Lack of Fit; Significance Level (p≥0.05)

moisture was diffusing out of the samples in which more moisture was retained in the samples compared with those dried at 55°C and 65°C. Moisture gets more excited at higher drying-air temperature and diffuses. ANOVA Table 1, revealed that the effect of drying-air temperature (D) was significant on the MR of samples at significance level of $p \leq 0.05$.

The effect of slice thickness on MR is shown in Figure 2 b. It is seen that the MR of samples sliced at 5.0 mm, 7.5 mm and 10 mm were 71.59 %, 71.89% and 71.29% respectively. This values were seen to be very close and the ANOVA Table 2 shows that the effect of slice thickness (B) was not statistically significant ($p \leq 0.05$) on the MR.

The effect of samples' variety on the MR of tomato is shown in Figure 2 c, it was found that *Hausa* variety had an average MR of 45.27%, *Tiwantiwa* variety had 84.25% and Roma *VFN* variety had 76.03%, these show that *Tiwantiwa* variety has the highest MR and *Hausa* variety has the lowest. This can be attributed to the high initial m.c. of *Tiwantiwa* variety which was 95.82% and low moisture content of *Hausa* variety which was 85.03%. While that of Roma *VFN* variety had initial moisture content of 93.76%. The difference in MR of the samples might be attributed to the microstructural characteristics of the tomato varieties as the cells of *Tiwantiwa* variety might be less porous and able to retain more moisture compared with others. The ANOVA Table 1 further reveals it that statistically the individual effect of tomato variety (C), its quadratic effect (C^2) and the interactive effect CD between variety and pre-drying treatment were highly significant statistically at $p \leq 0.05$ on the MR.

The effect of samples' pre-drying treatment on MR of treated tomato samples is shown in Figure 2 d samples pre-treated with ethyl acetate solution had 65.34% MR, those with $MgCl_2 \cdot 6H_2O$ and $Na_2S_2O_5$ solution had 80.21%, while those with NaCl solution had 66.95%, those pre-treated with mixture of honey and sugar solution had 74.11% and control samples had an average MR of 74.09%. This

observation would result from the hydrophilic property of $MgCl_2 \cdot 6H_2O$ which makes it highly hygroscopic in nature and therefore samples pre-treated in it has the highest MR. Ethyl acetate easily vaporizes into the air and not hygroscopic in nature and therefore was seen to have the least MR among others. As further shown by the ANOVA Table 1 statistically the effect of pre-drying treatment was significant on the MR of treated samples ($p \leq 0.05$).

3.1.2 Effects of Drying-air Temperature, Slice Thickness, Variety and Pre-drying Treatments on Effective Moisture Diffusivity

The effect of drying-air temperature on the effective moisture diffusivity (D_{eff}) of tomato samples is shown in Figure 3 a, it was seen that samples subjected to 65°C had highest D_{eff} of 1.69 x 10^{-8} m^2/s, 55°C had 1.20 x 10^{-8} m^2/s, while those subjected to 45°C had the lowest D_{eff} of 5.99 x 10^{-9} m^2/s, this agrees with the findings of Yilmaz et al. (2017), that increase in air temperature led to increase in D_{eff}. Results with this trend had been reported earlier by Jaiyeoba and Raji (2012) who had worked on the estimation of D_{eff} of Tomato and found that D_{eff} increases with increase in air temperature and also found that the D_{eff} of tomato was within 10^{-8} m^2/s. The highest D_{eff} observed in samples dried at 65°C can be attributed to the high level of drying-air temperature used which contains more heat energy required to activate the movement of water from the internal part of the products to their surface for drying to occur. As reported by Mewa et al. (2018), that water activity increases with increase in temperature which results in increase in D_{eff} of beef during drying. Analysis of Variance (ANOVA) Table 2, shows that the effect of drying-air temperature was highly significant on the D_{eff} of samples at $p \leq 0.05$, therefore the findings of Yilmaz et al. (2017) was replicated that effect of drying-air temperature was significant on the D_{eff} of pomegranate fruit leather.

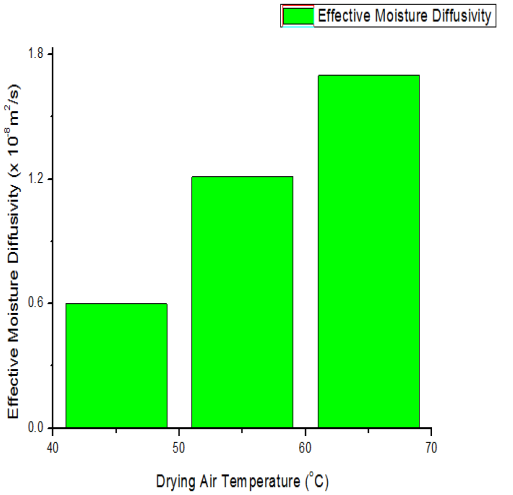

Figure 3 a: Effect of Air-temp. on Effective Moisture Diffusivity

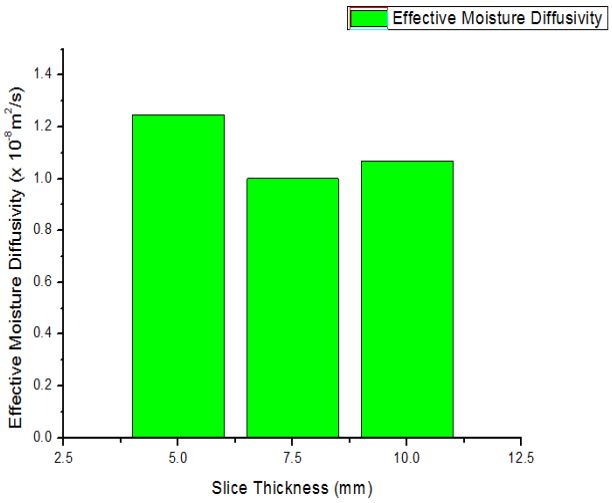

Figure 3 b: Effect of Slice Thickness on Eff. Moisture Diffusivity

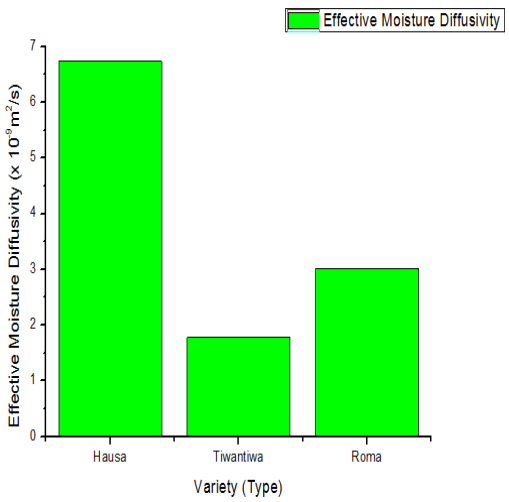

Figure 3 c: Effect of Variety on Eff. Moisture Diffusivity

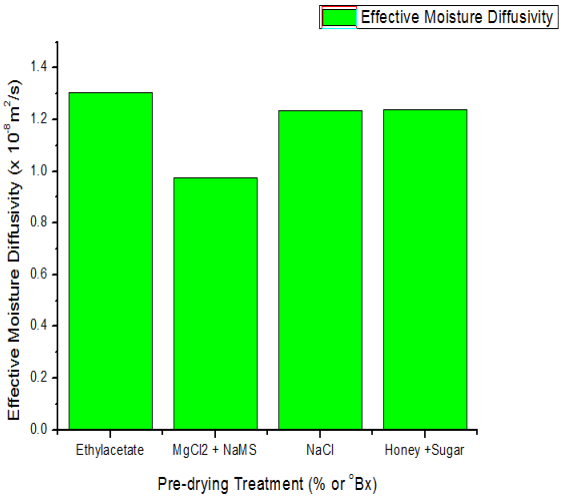

Figure 3 d: Effect of Pre-drying Treatment on Eff. Moisture Diffusivity

Table 2:Analysis of Variance for Effective Moisture Diffusivity of Tomato Slices

Source	Sum of Squares	DF	Mean Square	F Value	Prob.>F	
Model	4.107E-015	21	1.956E-016	4.81	< 0.0001	*Sig.*
A	1.043E-015	1	1.043E-015	25.63	< 0.0001	
B	1.575E-017	1	1.575E-017	0.39	0.5369	
C	1.574E-016	1	1.574E-016	4.36	0.0408	
D	1.040E-016	3	3.465E-017	0.85	0.4728	
A^2	9.811E-018	1	9.811E-018	0.24	0.6257	
B^2	1.433E-017	1	1.433E-017	0.35	0.5557	
C^2	2.492E-015	1	2.492E-015	61.26	< 0.0001	
AB	1.699E-019	1	1.699E-019	4.177E-003	0.9488	
AC	6.786E-019	1	6.786E-019	0.017	0.8978	
AD	2.452E-016	3	8.175E-017	2.01	0.1257	
BC	6.958E-020	1	6.958E-020	1.711E-003	0.9672	
BD	2.275E-017	3	7.582E-018	0.19	0.9051	
CD	2.528E-017	3	8.428E-018	0.21	0.8909	
Residual	1.871E-015	46	4.068E-017			
LOF	1.231E-015	30	4.103E-017	1.03	0.4949	
Pure Error	6.400E-016	16	4.000E-017			
Cor Total	5.978E-015	67				

LOF-Lack of Fit; Significance level ($p \geq 0.05$)

Effect of slice thickness on D_{eff} is found in Figure 3 b. The D_{eff} of tomato samples sliced at 5 mm, 7.5 mm and 10 mm were 1.25, 1.00 and 1.07 x10^{-8} m^2/s respectively. These values were seen to be quite close and the ANOVA Table 2 shows that the effect of slice thickness was not significant statistically at $p \leq 0.05$ on the D_{eff}. However, this is not in agreement to the report by Yilmaz et al. (2017) that increase in slice thickness results in increase in effective moisture diffusivity and states that slice thickness was statically significant on D_{eff}.

The effect of samples' variety on the D_{eff} of tomato is shown in Figure 3 c, it was found that *Hausa* variety had an average D_{eff} of 6.73 x10^{-9} m^2/s, Tiwantiwa variety had1.78 x10^{-9} m^2/s and Roma *VFN*

variety had 3.02 x10^{-9} m^2/s, these show that *Hausa* variety had the highest D_{eff} and *Tiwantiwa* variety had the lowest. These show that the samples with the highest moisture content tend to have lower effective moisture diffusivity than those with the lowest moisture content which have higher effective moisture diffusivity. *Tiwantiwa* variety had the highest initial moisture content of 95.82% and MR while *Hausa* variety had lowest initial moisture content of 85.03% and lowest MR. Roma *VFN* variety has initial moisture content of 93.76% and average MR. This was in agreement with the findings Sharma and Prasad (2004) in which it was found that D_{eff} is a function of samples' m.c. which increases gradually with decrease in m.c. The reason for this was that as m.c. decreased vapour phase diffusivity increased provided the pores were kept opened. The ANOVA Table 2 further reveals it that statically the individual effect of tomato variety (C) and its quadratic effect (C^2) were highly significant ($p \leq 0.05$) on the D_{eff}.

The effect of samples' pre-drying treatment on D_{eff}. of treated tomato samples is shown in Figure 3 d, samples pre-treated with ethyl acetate solution had 1.31 x10^{-8} m^2/s D_{eff}, those with $MgCl_2 \cdot 6H_2O$ and $Na_2S_2O_5$ solution had 9.76 x10^{-9} m^2/s, while those with NaCl solution had1.23 x10^{-8} m^2/s, those pre-treated with mixture of honey and sugar solution had1.24 x10^{-8} m^2/s and control had 8.425 x 10^{-9} m^2/s. Samples pre-treated with ethyl acetate solution had the highest effective moisture diffusivity while those pre-treated in $MgCl_2 \cdot 6H_2O$ and $Na_2S_2O_5$ solution had the lowest. From Figure 2 d it can be seen that samples pre-treated in ethyl acetate had the lowest MR while those pre-treated in $MgCl_2 \cdot 6H_2O$ and $Na_2S_2O_5$ solution had the highest MR. Therefore, the higher the MR the lower the effective moisture diffusivity and vice versa. This claim had also been found by Sharma and Prasad (2004) and Darvishi et al. (2016). As further shown by the ANOVA Table 2 statistically the effect of samples' pre-drying treatment was not significant on the D_{eff} of treated samples ($p \leq 0.05$).

4. CONCLUSION

1. Moisture ratio of tomato at any stage during the drying process reduces with increase in drying-air temperature but effective moisture diffusivity increases with increase in drying-air temperature
2. The moisture ratio of tomato was dependent on its variety which can be linked to its initial moisture content, also Pre-drying treatment of samples had strong influence on samples' MR and effective moisture diffusivity which can either increase or decrease it.
3. Samples' lowest MR were obtained under these conditions; processed *Hausa* variety, 10 mm thickness, Ethyl acetate pre-drying treatment and dried at 55ºC while highest effective moisture diffusivity was obtained under these conditions processed *Hausa* variety, 5 mm thickness, Honey and Sugar pre-drying treatment and dried at 65ºC in a FCCD.
4. Processed *Hausa* variety is more preferable to other varieties of tomato used; as it promotes low MR and high effective moisture diffusivity during the drying process. This will help reduced energy consumed during drying of tomato and will save processing time.

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Oral Session | Postharvest/Food Technology and Process Engineering
[5-1015-C] Postharvest/Food Technology and Process Engineering (5)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room C (3rd room)

[5-1015-C-04] Extending the Shelf-life of Upland Water Spinach (*Ipomoea aquatica*) Using Trimming, Modified Atmosphere Packaging (MAP) and Low-Temperature Storage

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Keywords: upland water spinach, modified atmosphere packaging, low temperature storage, postharvest, leafy vegetable

Upland Water Spinach (UWS) is highly perishable in nature and have a short shelf life (2 days). Small-scale farmers, traders, and restaurant owners sought simple, low-cost techniques to prolong its shelf-life. In this study, the effects of trimming of roots, modified atmosphere packaging (MAP) using polyethylene bag with 1 pinprick, and low temperature storage (20±0.5˚C and 10±0.5ºC) on the shelf life of UWS were evaluated based on its visual quality, yellowing, wilting, disease incidence and shelf-life. Results showed that at room temperature storage (29±1.0ºC), packed UWS had a higher shelf life (3days) compared to the unpacked ones (2 days), regardless of the presence of roots. At 20±0.5˚C storage, unpacked UWS without roots had a longer shelf life (3days) than those with roots (2days). Packed UWS at 20±0.5ºC, regardless of the presence of roots, had a longer shelf life (4 days) as compared to the unpacked ones. At 10±0.5ºC storage, unpacked UWS had a shelf life of 3 days. Among all treatments, packing UWS without roots in PEB with 1 pinprick in combination with storage at 10±0.5ºC extends the shelf life to 5 days, with notable delay in occurrence and reduction of the extent of wilting and yellowing. This practice can be used by small-scale farmers, traders, and restaurant owners to reduce daily procurement costs incurred for transportation, hauling and manpower.

Extending the Shelf-life of Upland Water Spinach (*Ipomoea aquatica*) Using Trimming, Modified Atmosphere Packaging (MAP) and Low-Temperature Storage

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ABSTRACT

Upland Water Spinach (UWS) is highly perishable in nature and have a short shelf life (2 days). Small-scale farmers, traders, and restaurant owners sought simple, low-cost techniques to prolong its shelf-life. In this study, the effects of trimming of roots, modified atmosphere packaging (MAP) using polyethylene bag with 1 pinprick, and low temperature storage (20±0.5°C and 10±0.5ºC) on the shelf life of UWS were evaluated based on its visual quality, yellowing, wilting, disease incidence and shelf-life. Results showed that at room temperature storage (29±1.0ºC), packed UWS had a higher shelf life (3days) compared to the unpacked ones (2 days), regardless of the presence of roots. At 20±0.5°C storage, unpacked UWS without roots had a longer shelf life (3days) than those with roots (2days). Packed UWS at 20±0.5ºC, regardless of the presence of roots, had a longer shelf life (4 days) as compared to the unpacked ones. At 10±0.5ºC storage, unpacked UWS had a shelf life of 3 days. Among all treatments, packing UWS without roots in PEB with 1 pinprick in combination with storage at 10±0.5ºC extends the shelf life to 5 days, with notable delay in occurrence and reduction of the extent of wilting and yellowing. This practice can be used by small-scale farmers, traders, and restaurant owners to reduce daily procurement costs incurred for transportation, hauling and manpower.

Keywords:
Upland water spinach
Modified atmosphere packaging
Low temperature storage
Postharvest
Kangkong

1. INTRODUCTION

Upland Water Spinach, also known as upland *kangkong* in the Philippines, is a leafy vegetable that grows rapidly (~25-30 days), is easily cultivated, and can thrive in most soil types (Goebel *et al.,* 2010) and various seasons throughout the year (Science and Development Network, 2013). In developing countries like Philippines, the importance of UWS has been recognized due to its availability in the market at a remarkably low price (Prasad *et al.,* 2008). Young leaves, petioles and stems used as viand, cooked alone or with meat or fish, while vines are used as fodder for cattle and pigs. More attention is continuously drawn to UWS due to its high nutritional value (protein, fiber, calcium, magnesium, iron, vitamins A, C, and E, folic acid, and phenolic compounds) and better appearance than low land water spinach (Dua *et al.,* 2015), as both market and consumers are driven towards healthier food choices.

UWS is highly perishable in nature and have a short shelf life (2 days). Effective yet simple and low-cost techniques in prolonging the shelf-life of UWS is sought by farmers, traders, as well as restaurants. Farmers and traders believe that trimming the roots of UWS will hasten its deterioration hence, selling UWS with roots has been their common practice. However, the roots can add to the bulk of vegetable handled and transported, may be source of contaminants in which concerns on safety and quality may arise, and may cause fraudulent addition to weight and price that can be burdensome for customers. This theory in trimming of roots was tested in this study.

Various techniques on modified atmosphere packaging (MAP), appropriate storage temperatures, and minimal processing were explored to maintain quality and reduce losses in leafy vegetables as recommended in published literatures such as Kitinoja and Kader (2002), Cantwell and Suslow (2006), Kanlarayat (2007), and Acedo (2010). However, the use of these techniques has not been reported for UWS in the Philippines. Hence, these techniques were studied to match the needs of concerned UWS small-scale farmers, traders and restaurant owners.

This study aims to prolong the shelf-life of upland water spinach using simple and low-cost techniques by determining the effect of trimming the roots, MAP using polyethylene bags with pinprick, and low temperature storage (20±0.5°C and 10±0.5ºC) on the shelf-life of UWS.

2. MATERIALS AND METHODS

2.1. Plant Materials

Freshly harvested 30 days old UWS with roots were obtained from a nearby vegetable farm in UPLB. These were placed in clean 20-kg capacity plastic crates and hauled immediately to the Postharvest Horticulture Training and Research Center (PHTRC) laboratory.

2.2. Sample Preparation

Damage-free UWS plants with tender leaves and stems were selected from the harvest pool. In the packing house, these were washed thoroughly using tap water and sanitized using 100 ppm hypochlorite solution (Suslow, 2000) and then drained. Samples were then air-dried in the minimal processing laboratory (operating temperature: 25ºC).

2.3. Treatment

Completely dried UWS were distributed for each treatment as stipulated in Table 1. Packed samples were tape-sealed in 0.02mm polyethylene bag (PEB) with 1 pinprick. Treatments were selected based on best practices taken from preliminary studies.

Table 1. Postharvest techniques to prolong the shelf-life of UWS.

Treatment	Packaging	Presence of Roots	Storage Temperature
No.	PEB / UNP[1]	WR / NR[2]	ºC
1	PEB	WR	29±1.0ºC
2	PEB	NR	29±1.0ºC
3	UNP	WR	29±1.0ºC
4	UNP	NR	29±1.0ºC
5	PEB	WR	20±0.5ºC
6	PEB	NR	20±0.5ºC
7	UNP	WR	20±0.5ºC
8	UNP	NR	20±0.5ºC
9	PEB	NR	10±0.5ºC

10	UNP	NR	10±0.5ºC

[1] packed in polyethylene bag with one pinprick = PEB, unpacked = UNP;
[2] with roots = WR; without / no roots = NR; N=100

Permeating the package with a pinprick-sized air passage creates a naturally induced modified atmosphere for the product, providing protection for water loss while allowing enough respiration to occur through the hole. Modified atmosphere packaging (MAP) is retains freshness and extends shelf life of fresh produce by inhibiting moisture loss and slow down respiration thereby maintaining its color, reducing loss due to product respiratory heat, and maintaining the natural fresh taste of produce (Acedo, 2010).

Unpacked samples were bundled using rubber bands and placed uncovered on clean trays, simulating storage practices of UWS in Filipino households. Packed and unpacked UWS were placed in temperature simulations of room temperature (29±1.0ºC), open-type display chiller temperature (20±0.5ºC) and door-type display chiller temperature (10±0.5ºC). These storage temperatures were chosen as these are used in local restaurants that sell fresh UWS and offer UWS in their menu. Each replicate weighs 250±0.50 grams and there are 10 replicates for each temperature studied.

2.4. Data Collection and Analysis

Being a leafy vegetable, the quality of upland water spinach is mainly based on appearance that can be discerned by the human senses such as freshness, shape, size, maturity, color, turgidity, freedom from defects such as rot, physical damage, yellowing, or wilting (Acedo, 2010). In this study, these parameters were scored using Visual Quality Rating (VQR) to consider all visual factors that may affect the physical appearance of commodities. Shelf-life was determined by the number of days wherein the samples are edible.

Visual quality, yellowing, wilting and disease incidence were evaluated daily using indices developed by PHTRC-UPLB (Table 2, 3). Samples were evaluated daily for these parameters until it surpassed the limit of marketability (VQR=3). All data obtained were subjected to statistical analyses using SAS V9.0.

Table 2. Visual quality rating for fruits and vegetables (Horticulture 109.1 Laboratory Manual, PHTRC-UPLB).

Visual Quality Rating	Description
9,8	Excellent, field fresh
7,6	Very good, trace defects
5,4	Good, defects minor
3	Fair, defects moderate, limit of marketability
2	Poor, defects serious, limit of edibility
1	Non-edible under usual condition

Table 3. Indices for wilting, yellowing, and disease incidence (Horticulture 109.1 Laboratory Manual, PHTRC-UPLB).

Index	Description		
	Wilting	Yellowing	Disease Incidence
1	None	Absent	Absent
2	Trace, <10% leaves wilted (mostly tips and edges)	Slight (up to 20% leaves discolored)	Slight (up to 20% leaves infected)
3	Slight, 10-25% leaves wilted	Moderate (21-40% leaves discolored)	Moderate (21-40% leaves infected)

4	Moderate, 26-50% leaves wilted	Severe (>40% leaves discolored)	Severe (>40% leaves infected)
5	Severe, <50% leaves wilted	Not applicable	Not applicable

3. RESULTS AND DISCUSSION

3.1. Visual Quality Rating (VQR) and Shelf-life

VQR for UWS were shown in Figure 1.a-c. Regardless of the type of packaging, trimming of roots did not affect VQR at 29±1.0ºC. PEB-packed UWS remained marketable until day 2, which shows that packaging in PEB with 1 pinprick extends the shelf life by 1 day at 29±1.0ºC (Table 4). On the other hand, rapid deterioration on visual quality can be observed in unpacked UWS at 29±1.0ºC from day 1 to day 2.

In samples stored at 20±0.5ºC, PEB-packed UWS were marketable until the fourth day of storage, regardless of the presence of roots while unpacked samples with roots had increased its shelf-life by 1 day. It can be noted that the shelf-life of PEB-packed samples, regardless of the presence of roots, also increased by one day at 20±0.5ºC.

At 10±0.5ºC, PEB-packed samples were marketable up to 5 days of storage while unpacked samples lasted for 3 days. The rapid decline in VQR of unpacked samples on the second storage day is notable.

The presence of roots did not have effects on the VQR and shelf-life of packed samples (Figure 1.a and b). This can be attributed to the protection provided by the packaging which inhibits water loss thereby retaining freshness of the leaves (Acedo, 2010). However, retails packs and bundles with trimmed roots are fuller in terms of useful portions (young leaves and stems) which may provide more value for the price of each pack and benefit consumers.

With the base UWS shelf-life of 2 days (control), storage in 20±0.5ºC and 10±0.5ºC in conjunction with PEB-packing with one pinprick increased the shelf-life of UWS by 1 day and 2 days, respectively. Among all samples in different storage temperatures, PEB-packed UWS without roots and stored at 10±0.5ºC had the superior VQR and remained marketable up to 5 days of storage.

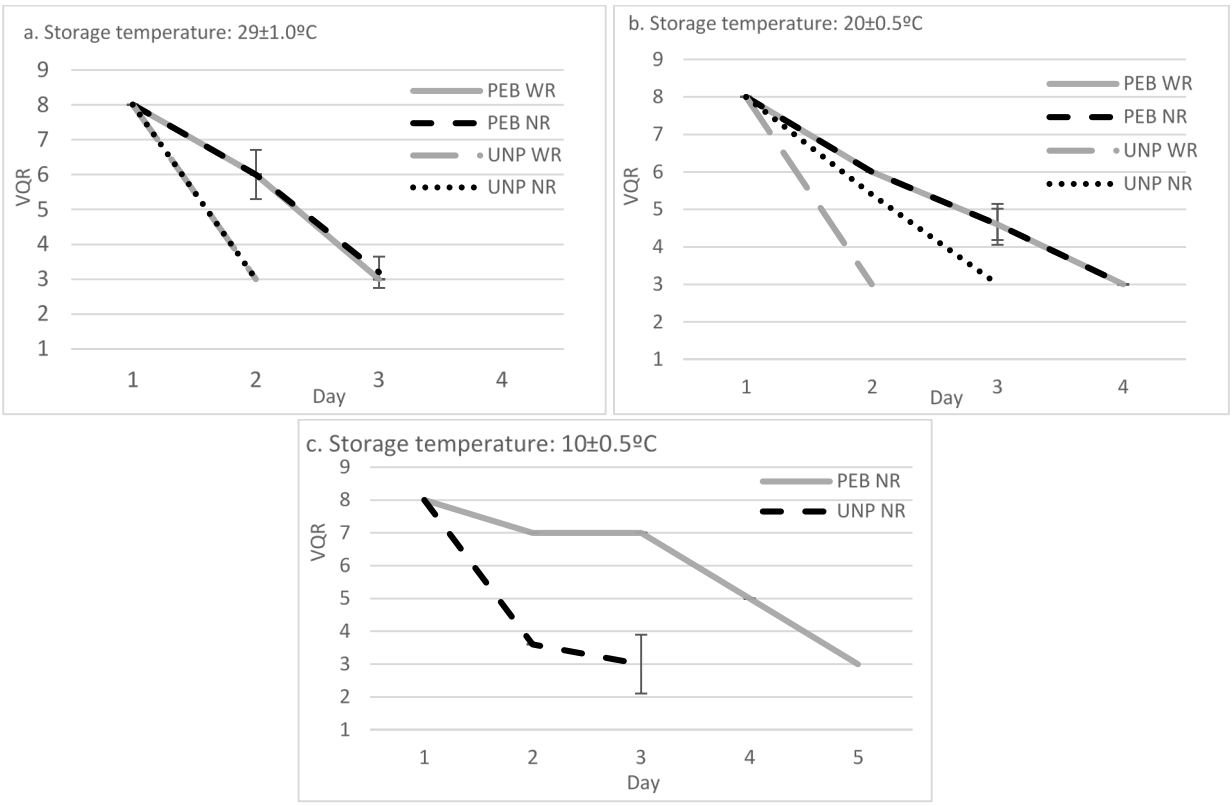

Figure 1.a-c. Visual quality rating for UWS stored at 29±1.0ºC, 20±0.5ºC and 10±0.5ºC (Packed in polyethylene bag with one pinprick = PEB, unpacked = UNP; with roots = WR; without / no roots = NR; VQR scores: 9,8= Excellent, field fresh, 7,6= Good, defects minor, 5,4= Fair, defects moderate, limit of marketability; 3= Poor, defects serious, 2=Limit of edibility, 1=non-edible under usual condition; N=100).

Table 4. Shelf-life of UWS stored at 29±1.0ºC, 20±0.5ºC and 10±0.5ºC ([1] Packed in polyethylene bag with one pinprick = PEB, unpacked = UNP; [2] with roots = WR; without / no roots = NR; N=100).

Treatment	Packaging	Presence of Roots	Storage Temperature	Shelf-life [3]
No.	PEB / UNP[a]	WR / NR[b]	ºC	Days
1	PEB	WR	29±1.0ºC	3c
2	PEB	NR	29±1.0ºC	3c
3	UNP	WR	29±1.0ºC	2d
4	UNP	NR	29±1.0ºC	2d
5	PEB	WR	20±0.5ºC	4b
6	PEB	NR	20±0.5ºC	4b
7	UNP	WR	20±0.5ºC	2d
8	UNP	NR	20±0.5ºC	3c
9	PEB	NR	10±0.5ºC	5a
10	UNP	NR	10±0.5ºC	3c

[3] Shelf-life values followed by similar letters are not significantly different from each other.

3.2. Yellowing

Yellowing was observed on all samples at the second day of storage except for the PEB with roots at 20±0.5ºC and samples at 10±0.5ºC (Figure 2.a-c.). Packed samples exhibited discoloration which can be attributed to exposure to its own ethylene. While MAP slows down respiration and protects the leaves from moisture loss, ethylene produced during senescence can build up inside the packaging with prolonged storage. This may cause yellowing, epinasty (leaf curving) and abscission (Cantwell and Suslow, 2006).

At 10±0.5ºC, yellowing was delayed until the third day of storage. This can be attributed to the effect of cold storage which slows down the rates of physiological changes that the commodity undergoes, thereby reducing its effects such as discoloration (Kitinoja and Kader, 2002).

No significant trends were observed on the response of UWS to MAP and presence of roots in relation to yellowing.

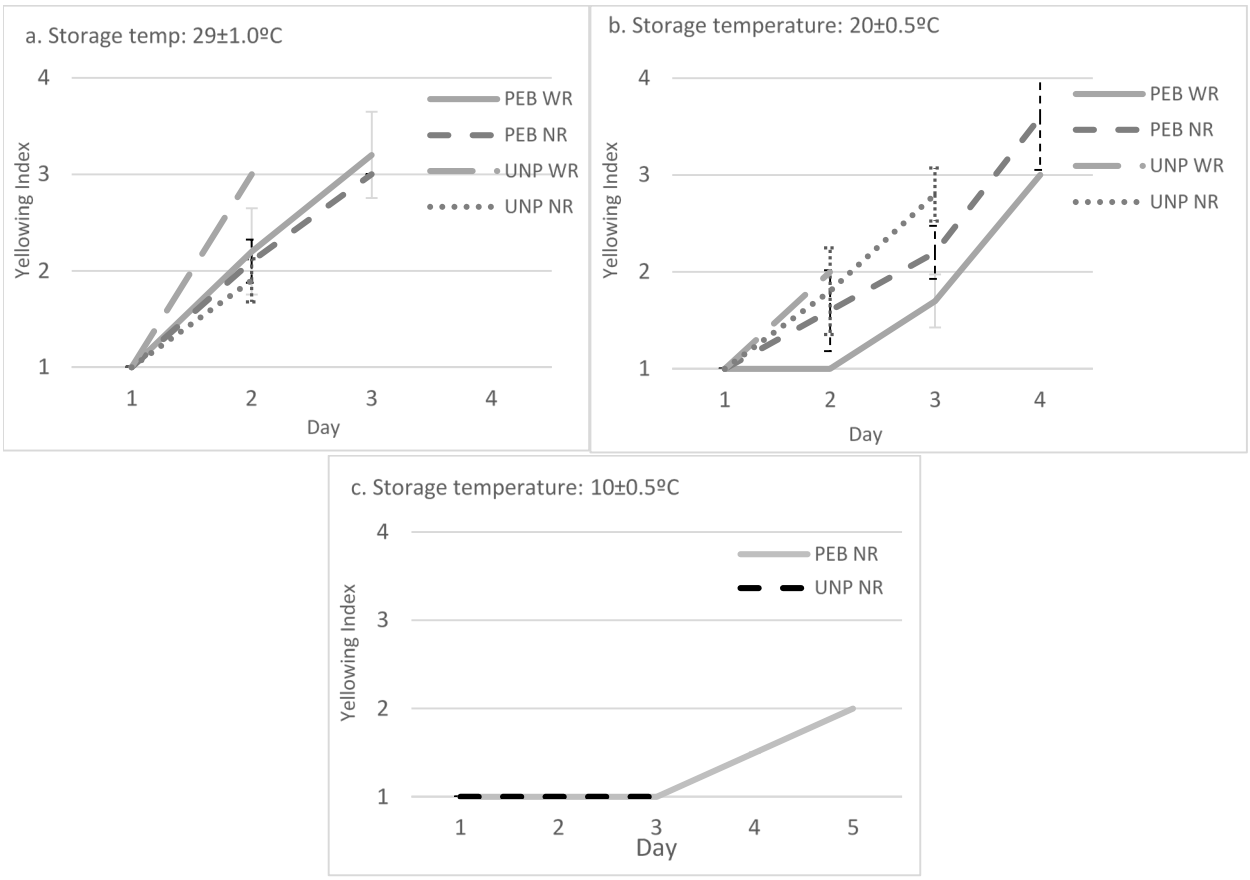

Figure 2.a-c. Yellowing in UWS stored at 29±1.0ºC, 20±0.5ºC and 10±0.5ºC (Packed in polyethylene bag with one pinprick = PEB, unpacked = UNP; with roots = WR; without / no roots = NR; Yellowing Index:1=absent, 2=Slight or 20%, 3= Moderate or 21-40%, 4=Severe or >40% of leaves discolored; N=100).

3.3. Wilting

Unpacked UWS had a significantly higher rate of wilting compared to the PEB-packed with 1 pinprick UWS in all storage temperatures (Figure 3.a-c.). This exhibits the effectiveness of MAP to decrease rates of moisture loss (Kitinoja and Kader, 2003).

Wilting was observed in PEB-packed samples only on the third day of storage in 29±1.0ºC and 20±0.5ºC. For the PEB-packed UWS in 10±0.5ºC, the incidence of wilting was delayed up to 4 days. On the other hand, no significant trends were observed on the response of UWS to presence of roots in relation to wilting.

It is important to reduce the incidence of wilting because it promotes degradation of nutritional components (e.g. vitamins and minerals) and imposes stress (i.e. water stress) that increases respiration and ethylene production. This should be prevented to maximize the health benefits of the vegetable. According to Kanlayanarat (2007), 5-10% in fresh weight make leafy vegetables appear wilted and unusable.

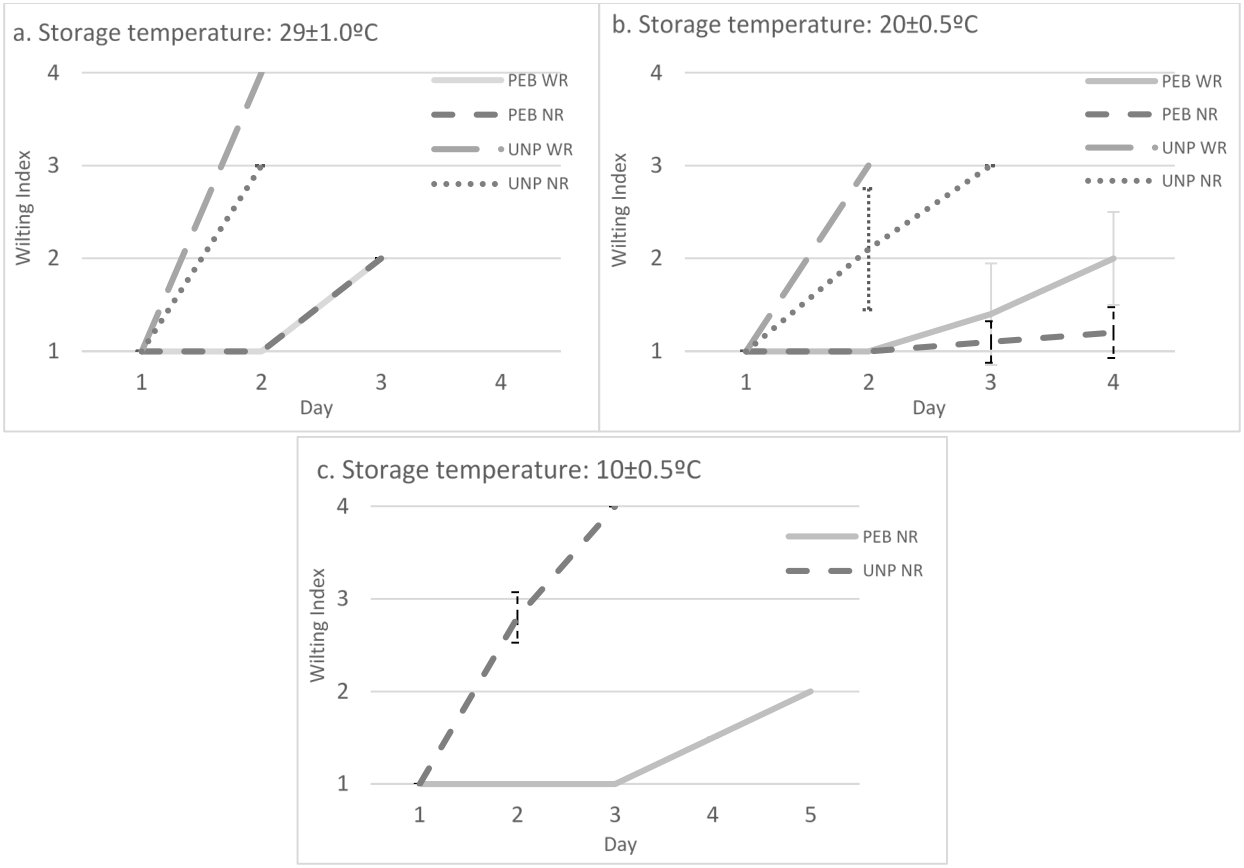

Figure 3.a-c. Wilting in UWS stored at 29±1.0ºC, 20±0.5ºC and 10±0.5ºC (Packed in polyethylene bag with one pinprick = PEB, unpacked = UNP; with roots = WR; without / no roots = NR; Wilting Index:1=none, 2=trace or <10%, 3=slight or 10-25%, 4=moderate or 25-50%, 5=severe or >50% wilted leaves; N=100).

3.4. Disease Incidence

Disease incidence was not observed on all samples (data not shown). This can be attributed to the systematic preparation of samples including washing with 100ppm hypochlorite solution and proper air drying.

According to the Philippine National Standards (Bureau of Agriculture and Fisheries Standards, 2016), washing with sodium hypochlorite solution is allowable for organically produced vegetables. The most effective concentration at the safe range is 100ppm (Suslow, 2000). Application of sanitizing agents may

help minimize the risk of a variety of biological hazards or contaminants such as *Salmonella sp., Escherichia coli, Listeria sp.,* and mycotoxins that pose food safety concerns leading to outbreaks (Herman *et al.,* 2015). At the same time, sanitation practices also reduce risk for bacterial soft rot, commonly caused by *Erwinia carotovora* (Tournas, 2005). This causes decay especially in packed leafy vegetables, since the packaging promotes build up of moisture that is promotes bacterial growth.

4. CONCLUSION

Regardless if packed or not, trimming of roots does not affect visual quality and shelf life of UWS at 29±1.0ºC and 20±0.5ºC except for the unpacked UWS. Trimming the roots and storing UWS unpacked at 20±0.5ºC extends the shelf life by 1 day.

Wilting was significantly delayed in samples packed in PEB with 1 pinprick compared to the unpacked ones in all storage temperatures. Packing in PEB with 1 pinprick extends the shelf life by 1 day at 29±1.0ºC (with or without roots), 2 days at 20±0.5ºC (without roots), 1 day at 20±0.5ºC (with roots) and 4 days 10±0.5ºC (without roots).

Yellowing was delayed for 1, 2 and 3 days in 29±1.0ºC, 20±0.5ºC and 10±0.5ºC, respectively. This shows the effectiveness of low temperature storage in delaying the incidence of yellowing. On the other hand, no significant trends were observed on the response of UWS to MAP and presence of roots in relation to yellowing.

Disease incidence was not observed on all samples. This can be attributed to the systematic preparation of samples including washing with 100ppm hypochlorite solution and proper air drying.

Given that the preparation of leaves in this experiment was followed, packing UWS without roots in PEB with 1 pinprick in combination with storage at 10±0.5ºC extends the shelf life to 5 days, with notable delay in occurrence and reduction of the extent of wilting and yellowing.

ACKNOWLEDGEMENT

This research is a portion of the project, "*Increasing Marketability and Availability of Safe and Quality Vegetables and Herbs: Implementation of Best Postharvest Handling Practices and Packaging Technologies*" funded by the Department of Agriculture – Bureau of Agricultural Research (DA-BAR) Philippines. The support of DA-BAR is greatly acknowledged.

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Oral Session | Postharvest/Food Technology and Process Engineering
[5-1015-C] Postharvest/Food Technology and Process Engineering (5)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room C (3rd room)

[5-1015-C-05] Investigation of Cowpea Variety and Storage Methods on Cowpea Beetle Infestation

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Keywords: cowpea beetle , polyethylene , Hessian bags , phostoxin , Aluminum bins

Investigation of effect of variety and storage methods on cowpea beetle (callosobruchus maculatus) infestation was carried out with the main aim of providing suitable, safe and affordable methods of storing various varieties of cowpea devoid of infestation. Three varieties of cowpea which are White, Brown and Black varieties were used. Various storage methods which include Plastics, Polyethylene, Hessian bags and Aluminum Bins of 10 kg capacity each were used in storing the cowpea. Twenty (20) cowpea beetle were introduced into the stored cowpea. Storage chemicals (Protoxin and Atelic dust) were put into the various stored cowpea at the same time of introducing the chemicals. The period of storage was four months. Completely randomized design (CRD) with four treatment and three replications were used for the experiment. Data collected include number of dead beetles, number of live beetle and number and percentage of damaged seed. The data were analyzed using analysis of variance (ANOVA). The result showed that Phostoxin and Atelic dust are toxic to the beetle in all the storage methods used leading to high mortality of the beetle though with less significant difference in the Hessian bag storage method. The result also showed that there is a strong significant difference among the treatment on White and Black varieties and no significant difference among the treatment on the Brown variety in terms of cowpea beetle damage. It was also found that Plastics and Polyethylene method of storage impaired respiration of the beetle leading to high mortality than in the Aluminum bin and the Hessian bag storage methods. Plastics and Polyethylene are therefore recommended for cheaper and environmentally safer for storage of cowpea. Also, the percentage of damage in the Black and White varieties were negligible and the period of storage with less infestation was longer than in the Brown variety.

Key words: cowpea beetle, polyethylene, Hessian bags, phostoxin, Aluminum bins.

1.0 Introduction

Cowpea (*vignaunguiculata*) (L) walp is a warm weather crop that is well adapted to drier region of the tropics like Nigeria where other food legumes do not thrive well. It is one of the most economically and nutritionally important indigenous African grain legumes produced throughout the tropical and subtropical areas of the world (Golob et. al., 1999). Nigeria is its largest producer and consumer, accounting for about 45 percent of its world production (Degri, 2008), while Africa account for about 75% (Brternburg et.al., 1995). Cowpea seed pods are consumed in fresh form as green vegetables in some African countries, while the rest of the cowpea plant serves as a nutritious fodder for livestock and also as a source of cash income when sold to farmers who use them as livestock feed. Cowpea seeds are also a rich source of minerals and obtains (Adeduntan et.al., 1998). Cowpea is sometimes called poor man meat or vegetable meat due to its high protein content. Cowpea grain contain 23.4% protein, 1.8 % fat and 60.3 % carbohydrates and also a good source of vitamins and phosphorus (Adediran and Akinneye. 2004).

In spite of the great value of cowpea particularly in Nigeria, their availability and utilization have been impaired due to the seed damage by insect pest particularly the larvae of cowpea beetle (*callosobuchusmaculatus)* (Ofuya and Lale, 2001). Attack by insect pest species begins in the field and continues in storage causing substantial damage to store grain legumes as the pest rapidly increase. It has been reported that both quantitative and qualitative losses arising from physical, chemical and biological factors e. g fungi, rodents birds and insect occur during storage of grains (Emeasor *et.al*., 2007). *Callusobruchusmaculatus*. Up to 100% infestation of cowpea can occur after three to six months storage (Maina, 2011).

Majority of farmers in Northern Nigeria and some other countries, including the Sudan, (Baribusta et. al, 2010) use local or indigenous storage facilities to forestall the menace of these insect pest they use storage insecticide where available and affordable like the banned and highly restricted lindens (gammalin A) and the acceptable are like Aluminum or Atelic EC for storing their legume grains against cowpea beets, termites, rats and disease pathogens (Degri,2007).

Some local plants have been studied to show they have effect against the activity of insect pest. They include; *NeemAzadiracta* (A.juss), Nicotine (*Nicotinia*spp), pyrethrum *chrysantheumceneraefolium*), Rotenme (*Derriselliptica*) (C.P.F, 1987). Sadim apple "Locally name Usher" (Calotropis*procera* (J.), Sesame (*Sesamumindicum* L.), Garlic (*AllumSativum* L.) and (Lantana Camara), (Mueller et. al., 1995). They were all found to lower fecundity per female and adult emergence (Singh et'al, 1996). But the availability and side effects of these are also a major concern to farmers. Hermetic storage technology has emerge as a potent alternative to other method of storage that protects commodities from insect and moulds have been developed and applied and they abound in type and the PICS (Purdue Improved Cowpea Storage) which was founded by the Bill and Melinda Gates foundation, is just one of these. The goal of the

project is to have 50 % of farm-stored cowpea in hermetic storage without insecticide in west and central Africa (Murdock et al., 2003). This is still on-going.

From the forgoing, some methods of cowpea beetle control abound but not without so many limitations, they are not cheap and some are also hazardous to health. Application of storage chemicals are sometimes not done properly by the local farmer which can lead to food poisoning. Larger quantity of cowpea are sold off immediately after harvest by the local farmers because of lack of adequate storage methods and fear of infestation by cowpea beetles thereby selling at a lower price compared to cost of production. This makes the produce scarce after the period of harvest.

This research was carried out to investigate the effect of variety and storage methods on the control of the cowpea beetle *Callosobruchus maculates (f) (coleopteran: Bruchide)* on stored cowpea. Effect of various storage methods on the control of cowpea beetle was also investigated as well as the variety that responds well to the various storage methods.

2.0 Materials and Methods

2.1 Sample collection and preparation

The following materials were used for the research, three varieties of cowpea: white variety (Kanannado), brown (Ife brown) and black (Akidi) variety. Insect pest cowpea beetle *callosobruchus maculates*, was used as the insect pest, which were introduced to each treatment at same level. The seed scanner also known as dianophoscope was used to scan the cowpea seed in order to detect the effect of insect damage from each treatment. The storage methods used in this research are polyethylene (hermetic), storage bins which are made of aluminum, plastic containers and hessian bags. The storage chemicals that were used are phostoxin and atelic dust. These chemicals were chosen because they are mostly used by farmers in Bauchi State and in the wrong proportion and application. All the experimental materials were purchased from a local grain market in Bauchi State, Nigeria.

2.2 Methods

2.2.1 Cleaning and Determination of Moisture content

The purchased cowpea were cleaned to remove debris and all other foreign materials, this was done by hand picking, sorting and using winnower. Moisture content of each of the cowpea variety were determined using standard methods as used by Abodenyi et. al., 2018. This was to ensure that the sample were at the safe storage moisture content to minimize spoilage during storage period.

2.2.2 Experimental procedures

2 kg of each variety were put in nine Polyethylene bags, the first three had phostoxine tablets introduced into it, and the next three had the atelic dust of 2 gm introduced into them, the last three served as control with no treatment. Each of the storage samples had Twenty (20) cowpea beetles introduced into them. These methods were repeated for the Aluminum storage bins, the Plastic containers and the Hessian bags for each variety. After introduction of the storage pest, the samples were agitated for one minute each to allow even spread of the pest and storage chemical (Ebiamadon et al., 2011)

The experimental set up were laid out in a completely randomized design with three replicates kept in the post-harvest laboratory of the department of agricultural bio-environmental engineering of federal polytechnic, Bauchi, Nigeria at 31$\pm$ 2 ^{o}C and a relative humidity of 65$\pm$5 for a period of 90 days

2.3 Data Collection and Statistical Analysis

The rate of infestation was determined for each variety after 90 days of infestation with the pest, the following data were collected.

1. Number of live and dead insects: this was counted manually and recorded from each treatment.
2. Percentage damage grains. The number of grains with holes and grains without roles in all the treatments in each variety: this was done by pouring the seed on a seed scanner to detect the damage seeds in each treatment, and manually counting the number of grains with holes and those without holes. The holes on the grain was used as an indicator of damage. Percentage grain damage was determined using the following formula.

$$percentage\ damage\ (\%) = \frac{number\ of\ damage\ grains}{total\ number\ of\ grain\ sampled}\ X100$$

Minitab statistical software was used in the analysis of variance (ANOVA) to determine the variation in results of all the experiments under the various independent variables and their interaction at 95% level. Descriptive statistics such as percentage was also used in presenting the data.

3.0 RESULTS

The results obtained are as presented in the tables below for the three varieties of cowpea

Table 1: Mean Effect of Cowpea Beetle Mortality on White Variety at 90 Days after Infestation

Treatments									
Storage methods	**Phostoxine**			**Atelic**			**Control**		
	Number of live beetles	Number of dead beetles	Percentage mortality (%)	Number of live beetles	Number of dead beetles	Percentage mortality (%)	Number of live beetles	Number of dead beetles	Percentage mortality (%)
Polyethylene Bags	1	19	95	3	17	85	7	13	65
Aluminum Bins	4	16	80	5	15	75	10	10	50
Hessian Bags	7	13	65	10	10	50	20	0	0
Plastic containers	0	20	100	3	17	85	6	14	70

Table 2: Mean Effect of Cowpea Beetle Mortality on Brown Variety at 90 Days after Infestation

Treatments									
Storage methods	**Phostoxine**			**Atelic**			**Control**		
	Number of live beetles	Number of dead beetles	Percentage mortality (%)	Number of live beetles	Number of dead beetles	Percentage mortality (%)	Number of live beetles	Number of dead beetles	Percentage mortality (%)
Polyethylene Bags	3	17	85	5	15	75	9	11	55
Aluminum Bins	6	14	70	6	14	70	15	5	25
Hessian Bags	9	11	55	11	9	45	20	0	0
Plastic containers	3	17	85	4	16	80	9	11	55

Table 3: Mean Effect of Cowpea Beetle Mortality on Black Variety at 90 Days after Infestation

Treatments									
Storage methods	**Phostoxine**			**Atelic**			**Control**		
	Number of live beetles	Number of dead beetles	Percentage mortality (%)	Number of live beetles	Number of dead beetles	Percentage mortality (%)	Number of live beetles	Number of dead beetles	Percentage mortality (%)
Polyethylene Bags	0	20	100	1	19	95	7	13	65
Aluminum Bins	3	17	85	5	15	75	11	9	45
Hessian Bags	7	13	65	8	12	60	20	0	0
Plastic containers	0	20	100	2	18	90	7	13	65

Table 4: Mean Percentage (%) of Damaged Cowpea at 90 Days after Infestation

Treatments									
Storage methods	**White variety**			**Brown variety**			**Black variety**		
	Phostoxine	Atelic	Control	Phostoxine	Atelic	Control	Phostoxine	Atelic	Control
Polyethylene Bags	10	12	40	15	15	50	8	10	30
Aluminum Bins	40	50	60	50	55	60	30	40	55
Hessian Bags	50	60	90	60	60	90	40	50	70
Plastic containers	9	10	35	12	20	40	8	10	30

3.1 Discussion

3.1.1 Cowpea Beetle Mortality on the various varieties of cowpea

The control treatment was generally less effective than the phostoxine and atelic dust at 90 days of storage and infestation of the cowpea. From tables 1, 2 and 3 all the storage methods were effective against the insect with significantly varying degree of efficiencies. Cowpea beetle mortality was significantly affected on the white variety more especially on the polyethylene storage and plastic containers with 95% and 100% mortality respectively. The Atelic showed mortality rate of 85 % for both polyethylene and plastic containers while the control treatment has a value of 65 % and 70 % for both the polyethylene and plastic containers respectively. The Aluminum bin showed 80% mortality on phostoxine combination, 75% for the atelic and 50 % for the control treatment. The reduction of oxygen during the 90 days of storage after the infestation reduced the insect count drastically especially in the polyethylene bags and the plastic containers. This cannot be said of the Hessian bags because they are porous and allowed the

thriving of the storage pest in all the treatments. This result agrees with the findings of (Ebiamadon et al., 2011) which researched the effectiveness of different botanical pesticides on control of *C. maculatus* at 30 and 90 days of infestation.

The mortality of cowpea beetle on the Brown variety, cowpea beetle mortality was significantly affected by the storage chemicals and the storage methods. Polyethylene together with phostoxine and plastic containers showed high mortality of 85 %. Atelic with polyethylene and plastic containers has mortality rate of 75 % and 80 % respectively. The control treatment indicated mortality of 55 %, this result agrees with PICS project (Villers, et al., 2008) which used the Hermetic storage methods by keeping away oxygen from the pest they were able to record 50 % mortality. The Hessian bags showed 0 % mortality for the control treatment.

Cowpea beetle mortality on the Black variety was significantly high after the 90 days infestation and storage for all the treatments and storage methods except for the Hessian bags that indicated 65 % for phostoxine, 60 % for atelic and 0 % for the control treatment.

3.1.2 Cowpea Damage at 90 Days after Infestation

Table four shows the degree of damage on the three varieties of cowpea after 90 days of infestation. The Hessian bag recorded the highest percentage of damage on all the storage methods and treatments for the three varieties. This can be attributed to the fact that the Hessian bag is porous that allowed intake of oxygen that allowed the survival of the storage pest. The White and black variety recorded less damage form the beetle from all the storage methods and treatments, this could be as a result of the high protein content of Brown beans, storage pest tend to fist more on highly protein food (AOAC, 2010)

4.0 Conclusion

From the above results, it can be concluded that the black variety is less susceptible to cowpea infestation when stored in a polyethylene bag as well as in an airtight plastic container.

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Oral Session | Others (including the category of JSAM and SASJ)

[5-1015-D] Other Categories (2)

Chair:Tri Yuliana(Universitas Padjadjaran, Indonesia)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room D (4th room)

[5-1015-D-01] Screening and Enzyme Activity of Cellulose-Producing Bacteria Isolated from Kemiri Sunan (*Reutealis trisperma* (Blanco) Airy Shaw) and Empty Fruit Bunches of Palm Oil

*Tri Yuliana[1], Efri Mardawati[1], Souvia Rahimah[1], Emilda Ayu Febrianty[1], Agus Try Hartono[1]
（1. Univ. Padjadjaran, Indonesia(Indonesia)）
10:15 AM - 10:30 AM

[5-1015-D-02] Development of a Cloud-based Internet of things Monitoring System for Fish Activity and Water Quality in Aquaponics

*Chien Lee[1], Yu-Jen Wang[1] （1. Department of Mechanical and Electromechanical Engineering, National Sun Yat-sen University(Taiwan)）
10:30 AM - 10:45 AM

[5-1015-D-03] EFFECT OF DIFFERENT MODES OF PLANTING AND WEEDING ON MACHINE FIELD CAPACITY AND YIELD OF A MIXED CROPPING SMALL HOLDER FARM

Folasayo Titilola Fayose[1], Adesoji Mathew Olaniyan[1], *Babatope Albert Alabadan[1], Anthony Ayodele Fajinmi[1], Kayode Ogunleye[1], Olanrewaju Omoju[1], Olufemi Aladejebi[1], Oluwaseun Ilesanmi[1] （1. Federal University Oye Ekiti(Nigeria)）
10:45 AM - 11:00 AM

[5-1015-D-04] Development of Agro-industrial Worker Trust Assessment System for Sustainable Ergonomic Program in Food Small and Medium-sized Enterprises

*Mirwan Ushada[1], Nur Achmad Sulistyo Putro[2], Titis Wijayanto[3], Fitri Trapsilawati[3], Nafis Khuriyati[1] （1. Universitas Gadjah Mada, Department of Agro-industrial Technology(Indonesia), 2. Universitas Gadjah Mada, Department of Computer Science and Electronics(Indonesia), 3. Universitas Gadjah Mada, Department of Mechanical and Industrial Engineering(Indonesia)）
11:00 AM - 11:15 AM

[5-1015-D-05] ASSESSING LAND USE TYPES IMPACT ON SOIL ORGANIC CARBON IN SOUTH WEST, NIGERIA

*OLORUNWA ERIC OMOFUNMI[1], ADESOJI MATTHEW OLANIYAN[1] （1. FEDERAL UNIVERSITY OYE-EKITI(Nigeria)）
11:15 AM - 11:30 AM

Oral Session | Others (including the category of JSAM and SASJ)
[5-1015-D] Other Categories (2)
Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room D (4th room)

[5-1015-D-01] Screening and Enzyme Activity of Cellulose-Producing Bacteria Isolated from Kemiri Sunan (*Reutealis trisperma* (Blanco) Airy Shaw) and Empty Fruit Bunches of Palm Oil

*Tri Yuliana[1], Efri Mardawati[1], Souvia Rahimah[1], Emilda Ayu Febrianty[1], Agus Try Hartono[1] (1. Univ. Padjadjaran, Indonesia(Indonesia))

Keywords: cellulose, Reutealis trisperm, Palm bunches, clear zone, enzyme activity

Biocatalyst technology is needed for the industry to improve performance of production. Cellulase enzymes has an important role in biocatalyst technology, especially in pulp industry. Cellulase is produced by certain types of microbes. The selection of cellulase-producing bacteria from Trisperma shell and empty fruit bunches from oil palm were carried out in order to produce cellulase which can be used for the pulp industry. Effectiveness test of cellulase-producing bacteria from Trisperma shell and palm bunches were also carried out using the liquid phase fermentation method. The result shows isolat K2 gave the widest clear zone with a value of 77.19% ± 0.00835 in BSM-CMC-CR media. OD value was calculated within 8 hours, 24 hours, 32 hours, and 48 hours in NB media. The result shows at 32 hours, the K3 isolate gave the highest absorbance with the value of 0.9163. Test of enzyme activity shown the K3 isolate had a highest enzyme activity with its value of 43.2 x 10-5 U/mL at 48 hours. The result of gram negative bacteria staining was assumed that the bacteria was *Pseudomonas* sp.

Screening and Enzyme Activity of Cellulose-Producing Bacteria Isolated from Kemiri Sunan (*Reutealis trisperma* (Blanco) Airy Shaw) and Empty Fruit Bunches of Palm Oil

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ABSTRACT

Biocatalyst technology is needed for the industry to improve performance of production. Cellulase enzymes has an important role in biocatalyst technology, especially in pulp industry. Cellulase is produced by certain types of microbes. The selection of cellulase-producing bacteria from Trisperma shell and empty fruit bunches from oil palm were carried out in order to produce cellulase which can be used for the pulp industry. Effectiveness test of cellulase-producing bacteria from Trisperma shell and palm bunches were also carried out using the liquid phase fermentation method. The result shows isolat K2 gave the widest clear zone with a value of 77.19% ± 0.00835 in BSM-CMC-CR media. OD value was calculated within 8 hours, 24 hours, 32 hours, and 48 hours in NB media. The result shows at 32 hours, the K3 isolate gave the highest absorbance with the value of 0.9163. Test of enzyme activity shown the K3 isolate had a highest enzyme activity with its value of 43.2 x 10-5 U/mL at 48 hours. The result of gram negative bacteria staining was assumed that the bacteria was *Pseudomonas* sp.

Keywords: *Reutealis trisperm, Palm bunches, cellulose, clear zone, enzyme activity*

10:30 AM - 10:45 AM (Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room D)

[5-1015-D-02] Development of a Cloud-based Internet of things Monitoring System for Fish Activity and Water Quality in Aquaponics

*Chien Lee[1], Yu-Jen Wang[1] (1. Department of Mechanical and Electromechanical Engineering, National Sun Yat-sen University(Taiwan))

Keywords: Aquaponics, Aquaculture, Internet of Things, Fish Activity, Oxygen Transfer, Water Quality

A cloud-based Internet of things monitoring system in aquaponics is proposed in this study. The system can use commercial sensors to measure water temperature, water depth, the amount of oxygen dissolved in water, and water *pH* . Moreover, three infrared distance sensors were attached to the aquarium glass at different heights to estimate fish school activity and provide an alternative alarm system for indicating an abnormal water level in the tank. Water depth sensing in the rearing tank can be used to evaluate the ebb-and-flow irrigation function and estimate the flow rate of water circulation. A novel oxygen transfer model was set up in this study, the results of which prove that fish activity influences water quality. The model also indicates how to use regression analysis for diagnosing problems. Fish activity measurements can be used to estimate water quality or cross-check sensor types and provide proactive precursors to variations. The measuring module containing sensors and sub-1 GHz communication can transmit data through a 1-km-long gateway module. Finally, the data are uploaded to ThingSpeak™, a cloud platform, through Wi-Fi. By using the data stored on the cloud, a real-time alarm system for indicating abnormalities is developed and a periodic regression analysis is conducted using the cloud-based programming of ThingSpeak™.

10:45 AM - 11:00 AM (Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room D)

[5-1015-D-03] EFFECT OF DIFFERENT MODES OF PLANTING AND WEEDING ON MACHINE FIELD CAPACITY AND YIELD OF A MIXED CROPPING SMALL HOLDER FARM

Folasayo Titilola Fayose[1], Adesoji Mathew Olaniyan[1], *Babatope Albert Alabadan[1], Anthony Ayodele Fajinmi[1], Kayode Ogunleye[1], Olanrewaju Omoju[1], Olufemi Aladejebi[1], Oluwaseun Ilesanmi[1] (1. Federal University Oye Ekiti(Nigeria))

Keywords: planting, weeding, field capacity, yield

Nigeria has great potential for cultivation of a wide variety of crops as its soil and climatic conditions are suitable for crop cultivation. However, growing crops with human labour (planting, weeding) has been the common practice. After an initial conventional tillage, labour saving mechanical jab and rotary planters, reciprocating weeder and manual methods were used to establish a mixed cropping one hectare farm of maize and cassava under rain-fed conditions The effects of these treatments were studied using the following parameters: field capacity of planting, weeding and yield of crops. The highest field capacity among the planting modes was that of rotary planting with 1.53 ha/hr while, 0.44 ha/hr and 0.24 ha/hr were obtained for jab and manual planting respectively. A field capacity of 0.012ha/hr was obtained for mechanical weeding as against 0.0036 ha/hr with manual weeding. The yields of the maize stover are as follows: Manual planting 6.9 tonnes/ha, Rotary planting 11.5 tonnes/ha, Jab planting 3.9 tonnes/ha while that of the average ear weight are 15.42 tonnes/ha for rotary planting, 10.33 tonnes/ha for manual planting and 5.83 tonnes/ha for jab planting. The effect of the use of chemical weeding reduced the yield of cassava roots to 60 ton/ha as

against 81 ton/ha for manual/mechanical weeding. Further investigation is ongoing to substantiate the facts. However, these observations are in agreement with the fact that mechanical manipulation of the soil by way of planting and weeding loosen the soil between rows, thus increasing air and water intake capacity, thereby increasing yield.

11:00 AM - 11:15 AM (Thu. Sep 5, 2019 10:15 AM - 11:30 AM Room D)

[5-1015-D-04] Development of Agro-industrial Worker Trust Assessment System for Sustainable Ergonomic Program in Food Small and Medium-sized Enterprises

*Mirwan Ushada[1], Nur Achmad Sulistyo Putro[2], Titis Wijayanto[3], Fitri Trapsilawati[3], Nafis Khuriyati[1] (1. Universitas Gadjah Mada, Department of Agro-industrial Technology(Indonesia), 2. Universitas Gadjah Mada, Department of Computer Science and Electronics(Indonesia), 3. Universitas Gadjah Mada, Department of Mechanical and Industrial Engineering(Indonesia))

Keywords: Bird swarm algorithm, Collective trust, Environmental ergonomics, Individual trust, Kansei Engineering

Ergonomic program has not yet fully gained the worker trust in food Small Medium-sized Enterprises (SMEs) due to the gap between ergonomics and financial amenities. The tangible financial amenities as wages, incentives, and insurance have been more attractive than the intangible ergonomics program in the form of a comfortable workplace environment (Environmental ergonomics), efficient work methods and optimum workload. Trust could be defined as an abstractive (Kansei) human factor which is characterized by uncertainty and vulnerability to support their individual and collective decision. Trust influence the attractiveness of ergonomic program to worker as individual and worker union as the collective. The abstractive communication between 1 (one) individual worker and other partners in same union is possible to be simulated in an artificial bird swarm algorithm. Kansei engineering was selected to model the individual trust due to the reliability for modeling the abstractive human factors. Artificial swarm intelligence was selected to simulate the collective trust due to capability to model non-linear of human factors. The research goal was to develop an agro-industrial worker trust assessment system for sustainable ergonomic program in food SMEs. The research objective was: 1) To predict the worker individual trust using Kansei Engineering; 2) To simulate the worker collective trust using bird swarm algorithm. The system is expected to assist the SME' s management for developing trust evidence-based ergonomic policy. Generally, the system is expected to support the Sustainable Development Goals numbers 3 (Good health &well-being) and number 9 (Industry, innovation and infrastructure). The system was tested on the database of worker human factors in Food SMEs. The inputs of the system was extracted from database as: 1) Workload; 2) Workplace temperature; 3) Relative humidity; 4) Light intensity; 5) Incentive. The output was individual and collective trust. The agro-industrial worker trust assessment system consists of 7 sub-systems. In the Sub-system 1, measurement is carried out to obtain the worker mood states, heart rate and workplace environment parameters. In Sub-system 2, the manager obtain measurement result in Sub-system 1 as the input to determine integrated workload and workplace temperature set point. If the workload indicated the normal status, then the workplace temperature is set. If the workload status indicated under or over load, then the system provides feedback for the manager to evaluate the existing ergonomic program. In Sub-system 3, the temperature was set in an air conditioner to create the comfortable workplace environment (Environmental ergonomics). In Sub-system 4, the work incentive is determined based on integrated workload (Sub-system 2) and environmental ergonomics (Sub-system 3). The individual trust index is determined in Sub-system 5. If

the index indicated the status of trust, the system proceeds the status to the Sub-system 6. If the index indicated distrust, the system provides feedback to the manager to evaluate the existing ergonomic program. The Sub-system 6 processes the individual trust in Sub-system 5 using the Bird Swarm Algorithm in Kansei Engineering (BISAKE). The algorithm simulated the worker union to behave like a bird swarm in determining whether an individual trust is satisfied or not against their mentality constraints of prior knowledge, familiarity, agreement and preference. Finally, in the Sub-system 7, the collective trust was validated. The simulation result indicated that worker trust index could be assessed based on workload status, a percentage of incentive and workplace environmental cost per month. Furthermore, this assessment could make the trust data more manageable to store, retrieve and enable interchange in big data system for sustainable ergonomic program in food SMEs.

Oral Session | Others (including the category of JSAM and SASJ)
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*OLORUNWA ERIC OMOFUNMI[1], ADESOJI MATTHEW OLANIYAN[1] （1. FEDERAL UNIVERSITY OYE-EKITI(Nigeria)）

Keywords: Federal University Oye Ekiti (Ikole campus), land use type, Soil organic carbon, Soil properties

The amount of soil organic carbon (SOC) stored in a particular soil is influenced by several factors including climate, vegetation type, land management, soil properties and current and last land use. The impacts of land use types on soil organic carbon were assessed. Four land use types were used in the study. Sampled soils were tahen at depth of 0 - 45 cm and at intervals of 15 cm. The soil samples were examined in accordance with the standard methods described by the American Public Health Association (APHA). The data were analyzed using descriptive statistics. The results showed the mean soil organic carbon content was higher under oil palm plantation land [D] compared with ther land use types at 0 - 15 cm soil depth (22.87g/kg) which was 1.5, 2.6 and 53.3 % more than in the Faculty of Agriculture Teaching and Research farm land [A], the cashew plantation land [B] and the Agricultural and Bioresources experimental farm land [C] respectively. This could be attributed to the greater inputs of vegetation (litter fall) and reduced decomposition of organic matter. Similarly, the lowest soil organic carboncontent under land use type C could be due to reduced inputs of organic matter and frequent tillage which encouraged oxidation oforganic matter. The finding indicated that the means of SOC in land use types were no significantly different (p = 0.05) except in the land use type C. It is concluded that land use types have influenced on soil organic carbon

ASSESSING LAND USE TYPES IMPACT ON SOIL ORGANIC CARBON IN SOUTH WEST, NIGERIA

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ABSTRACT

The amount of soil organic carbon (SOC) stored in a particular soil is influenced by several factors including climate, vegetation type, land management, soil properties and current and past land use. The impacts of land use types on soil organic carbon were assessed. Four land use types were used in the study. Sampled soils were taken at depth of 0 – 45 cm and at intervals of 15 cm. The soil samples were examined in accordance with the standard methods described by the American Public Health Association (APHA). The data were analyzed using descriptive statistics. The results showed that mean soil organic carbon content was higher under the oil palm plantation land use [D] compared with other land use types at 0 – 15 cm soil depth (22.87±3.89 g kg^{-1}), which was 1.5, 2.6 and 53.3 % more than in the Faculty of Agriculture Teaching and Research farm land A], the cashew plantation land [B] and the Agricultural and Bioresources experimental farm land [C] respectively. This could be attributed to greater inputs of vegetation (litter fall) and reduced decomposition of organic matter. Similarly, the lowest soil organic carbon content under land use type C could be due to reduced inputs of organic matter and frequent tillage which encouraged oxidation of organic matter. The finding indicated that the means of SOC in land use types were no significantly different (P = 0.05) except in the land use type C. It is concluded that land use types have influenced on soil organic carbon

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