CHARACTERIZATION OF DYE EXTRACTED FROM CASHEW (*Anacardium occidentale*) FRUIT JUICE

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Abstract: Cashew (*Anacardium occidentale*) fruits were collected from Girei Local Government Area of Adamawa State in Nigeria and dye extracted using ethanol as solvent. Ethanol was removed using rotary evaporator and dye extract was characterized by UV-Visible, FTIR, GC and MS spectrophotometers. The UV-Visible spectra indicated peaks at 195, 218, 263, 298, 358, 379 and 658 nm. FTIR spectrum indicated band at 2930 and 2860 cm^{-1} corresponded to C-H stretching vibration, 1711, 1602 and 1514 cm^{-1}, corresponded to C=O stretch of amide, C=C of aromatic hydrocarbon and N-H, respectively. These chromophoric groups may be responsible for the formation of red-orange-yellow colour of the dye extract. Compounds such as N.N-Dimethyl-o-(1-methyl-butyl-)hydroxylamine and 2,4,7,14-Tetramethyl-4-vinyl-tricyclo[5,4,3,o(1.8)]tetradecan-6-ol and N,N'-Bis(Carbobenzyloxy)-lysinemethyl(ester) were obtained by GC and MS spectra. It was then concluded that the dye extract could be a mixture of compounds belonging to the family of anthocyanins. Therefore, interaction between these coloured substances with cellulose could lead to the formation of strong bonds which may be difficult to break by common surfactants thereby creating a near permanent stain on the material.

Keywords: Cashew, *Anacardium occidentale*, natural dyes, anthocyanins fruit juice

Introduction

Dyes from natural sources are usually found in small amounts mixed with other non-dye materials (Kumar & Sinha, 2004). Plant a major source of natural dye has continues to draw more attention by the food and textile industries as substitutes for synthetic dyes (Hoffman & Geotz, 2008). The amount of dye in plants depends on the age, part of the plant, and agro climatic conditions (Saxena & Raja, 2014). Their application on substrate to give good shades however, requires large quantity of the dye (Kumaresan *et al.,* 2011). A number of studies have been done comparing the use and performance of natural and synthetic dyes on wool, silk and cotton (Dass *et al*., 2016; Jothi, 2008). Although, textile fabrics have been dyed using natural dye extensively, information on the chemistry vis a viz the identification and characterization of the natural dyes is still of huge interest (Deveoglu *et al.*, 2012).

Spectroscopic studies of natural dyes have greatly assisted in the elucidation of their structural properties. However, natural dyes have found to be present as mixture of closely related compounds therefore, limiting spectroscopic measurements (Espinosa-Morales *et al*., 2012). The use of high performance chromatographics, ultraviolet-visible, Fourier transform infrared and mass spectroscopy have been widely used (Espinosa-Morales *et al*., 2012). Another difficulty that is associated with the characterization of natural dyes is method of isolation of the individual compound (Prusti *et al*., 2009; Umale & Mahanwar, 2012). Both colorimetric and spectroscopic investigations are now commonly used (Ghann *et al*., 2016 & Wanyama *et al*., 2014). The continuous interest shown in natural dyes are due their numerous advantages over synthetic dyes such as low energy required for extraction, non- toxic, environment friendly and non-hazardous. Its growing demand for use in cosmetics, food, beverages, domestic utensils, textiles etc are among the reason for this studies (Samanta & Agarwal, 2009). This study is aimed at the characterization of dye extract of cashew (*Anacardium occidentale*) fruit juice by spectroscopic methods.

Materials and Methods

Collection of raw material

Potential dye-yielding plant namely Cashew (*Anacardium occidentale*) from the family of *Anacardiaceae* were collected in April, when the fruits were predominantly available, from Girei Local Government Area of Adamawa State-Nigeria. The fruit was authenticated by a botanist in the Biological Science Department, Modibbo Adama University of Technology Yola, Adamawa State, Nigeria.

Sample preparation

Ripped and undamaged cashew fruits collected (Fig. 1) were thoroughly washed in overflowing water before the nuts were detached from the fruits. The fruits were rewashed to remove any form of dirt between the nuts and the fruits. The fruits were then sorted and washed with 350 ppm sodium metabisulphite solution then weighed.

Fig. 1: Matured cashew fruit (*Anacardium occidentale)*

Extraction of dye from cashew juice

800 g of ripped cashew fruit were reduced by cutting into smaller size and grated in an electric mixer. About 400 g of cashew paste was placed in a flask and 800 ml of ethanol was added into the flask, shake and allowed to settle for 72 h. The liquid portion was decanted into a flask. The process of separating the liquid from the solid was repeated for thrice. 25 ml of NaCl solution was added to the juice extract (Fig. 2) in a separatory funnel to remove the water layer. To the extracted organic layer, 25 ml of 10% K_2CO_3 was added, and then placed into the separatory funnel for the removal of the water

layer. NaCl was then added again to the organic layer to remove more water. $MgSO_4$ solution was then added until clumping subsided in order to remove water that the previous processes were unable to. Finally, the dye extract was concentrated by evaporating solvent using rotary evaporator at 40-60°C for 4 h (Fig. 3) (Arlene & Anggraini, 2015) before characterization.

Fig. 2: Cashew (*Anacardium occidentale*) juice

Fig. 3: Crude dye extract

Characterization of some chemical properties of the dye extract using spectrophotometry

Ultraviolent-visible absorption of the dye extract was measured using Agilent Technologist Thermoscientific 7265 UV-Visible spectrophotometer. The Buck Scientific M530 Infrared spectrophotometer was used to measure the absorption band of the functional groups present in the dye extract. The Agilent Technologist Gas Chromatography 7890A coupled with mass spectrometer 5975 C was used in order to provide information about the structural properties of the dye extract.

Results and Discussion

Characterization of some chemical properties of the dye using spectrophotometry

Figure 4 gives the UV-visible absorption spectra of the cashew dye extract with peaks between 200 – 700 nm. This could be due the presence of a mixture of compounds but peak at 658 nm indicates the presence of a coloured compound (Arlene & Anggraini, 2015).

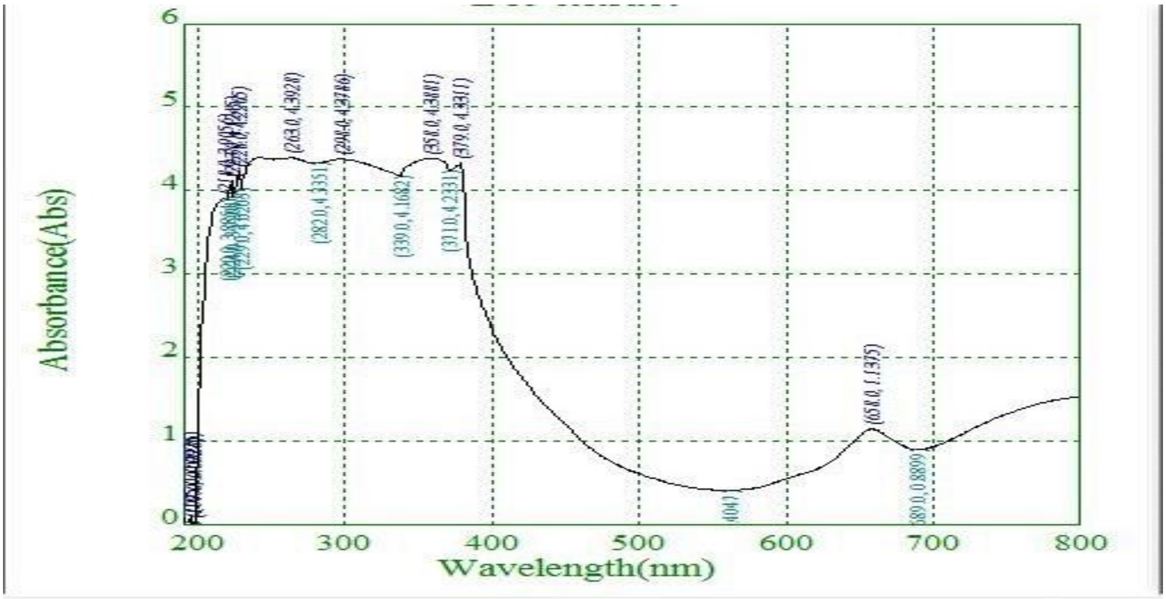


Fig 4: UV-Visible spectra of dye extract

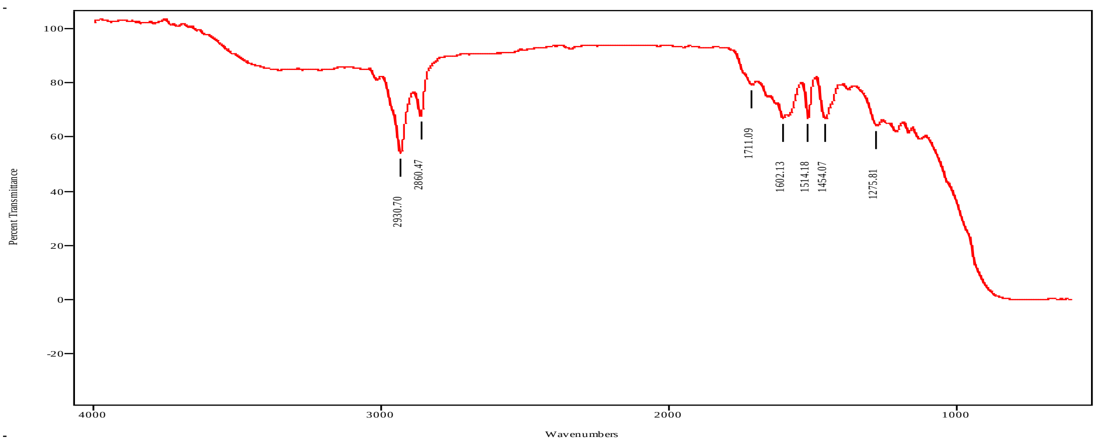


Fig. 5: Infrared spectrum of *Anacardium occidentale* dye extract

Figure 5 gives the infrared spectra of the cashew dye extract Table 1 gives the summary of the different types of chromophores. The absorption bands and their corresponding functional groups are identified. Functional groups such as C=O, C=C, N-H, C-O and C-H could be the chromophoric groups responsible for the formation of the red-orange- yellow colour of the cashew (*Anacardium occidentale*) dye extract (Fig. 3).

Table 1: Infrared spectra of *Anacardium occidentale* dye extract

Peaks	Wave length	Intensity	Functional Group
1	2930	Medium	C-H
2	2860	Weak	C-H
3	1711	Weak	C=O of amide
4	1602	Weak	C=C of aromatic
5	1514	Medium	N-H confirmation
6	1464	Medium	C-H bending
7	1275	Medium	C-O

Figures 6 to 8 give the GC-MS spectral patterns of *Anacardium occidentale* dye extract. Compounds identified are N.N-Dimethyl-o-(1-methyl-butyl-)hydroxylamine and 2,4,7,14-Tetramethyl-4-vinyl-tricyclo(5,4,3,o(1.8))tetradecan-6-ol and N,N'-Bis(Carbobenzyloxy)-lysinemethyl(ester), Tetraacetyl-d-xylonicnitril, Methanocyclopenta(a)cyclopropa(e)cyclodecen-11-one, 7,8-poxylano stan-11-ol, 3-acetoxy- and Hexadecanoic acid. Many dye extracted from plant sources and characterized by spectrometric methods have been shown to possess polar groups' characteristic of organic acids and phenolic compounds (Espinosa-Morales *et al.*, 2012). These compounds may be attributed to the family of anthocyanins and could be responsible for the characteristic red –orange-yellow colour (Sarpate *et al*., 2010). Interaction between these substances and cellulosic material may lead to the formation of strong bonds especially between nitrogen and carbon atoms (Divya & Ravi, 2013; Sharmin *et al*., 2016). This could be the reason for the difficulty in breaking the dye-cellulosic bond by common surfactants thereby creating a near permanent stain on the material.

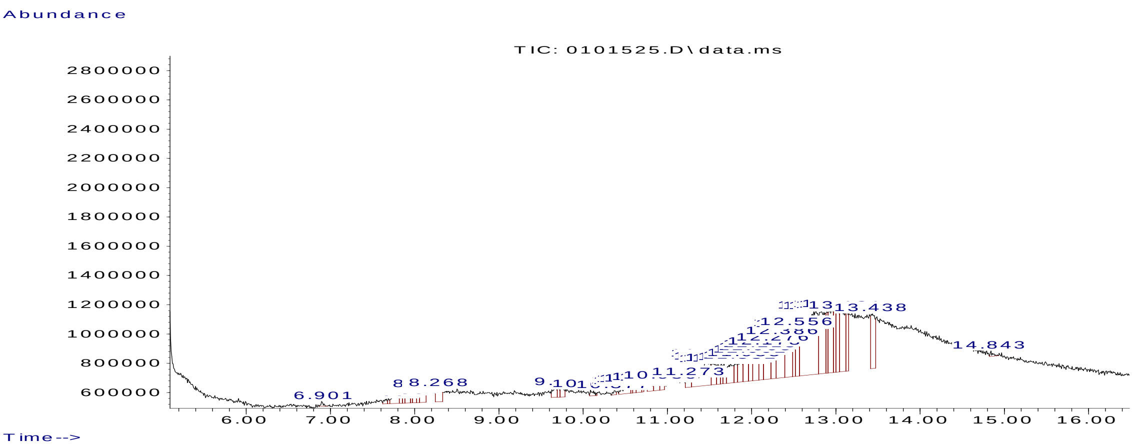


Fig. 6: GC chromatogram fragmentation of *Anacardium occidentale* dye extract

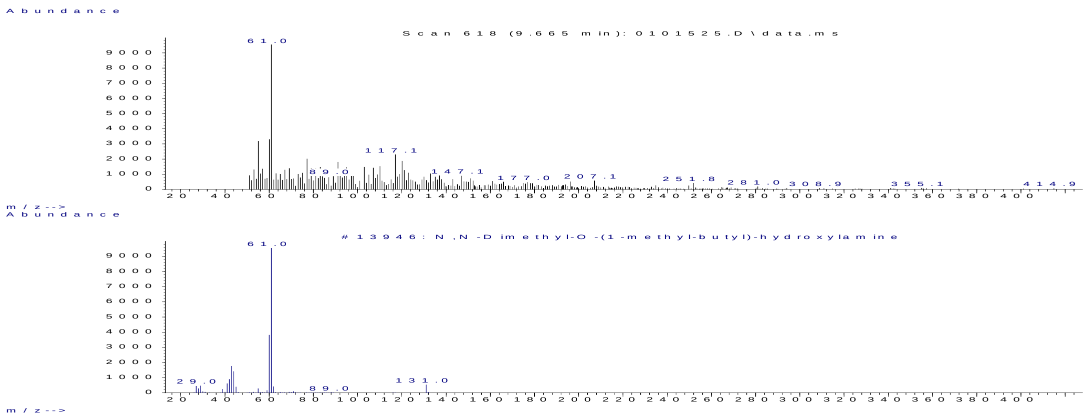


Fig. 7: MS fragmentation of *Anacardium occidentale* dye extract

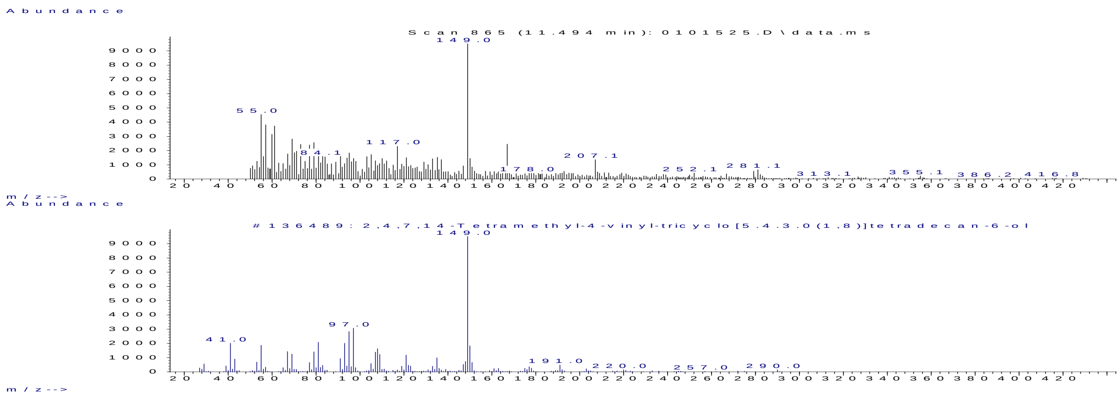


Fig. 8: MS fragmentation of *Anacardium occidentale* dye extract

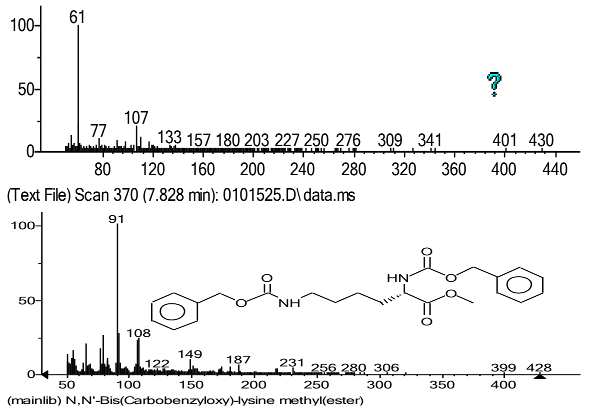


Fig. 9: MS fragmentation of *Anacardium occidentale* dye extract

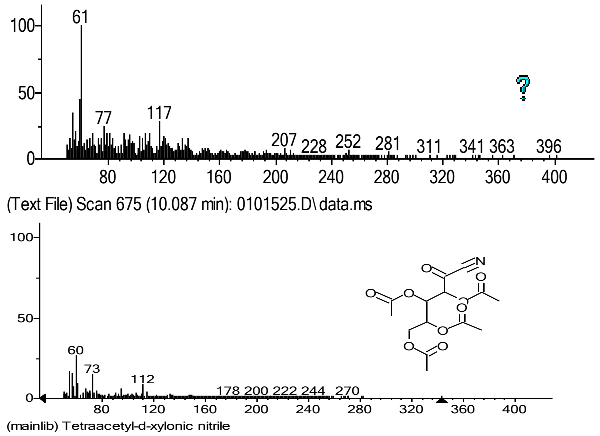


Fig. 10: MS fragmentation of *Anacardium occidentale* dye extract

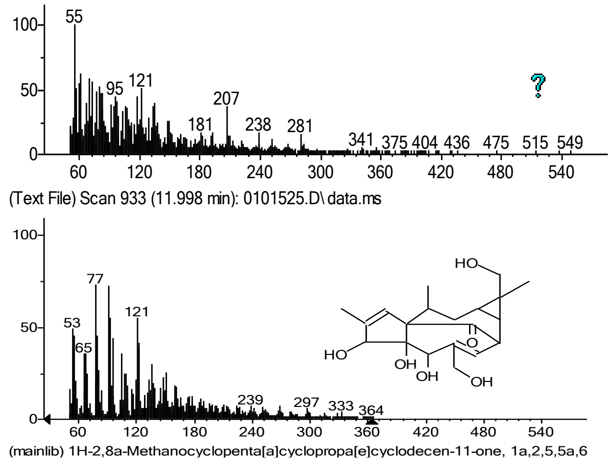
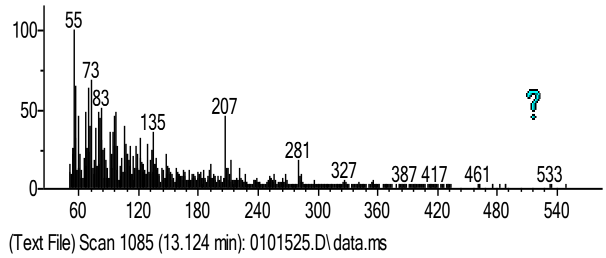


Fig. 11: MS fragmentation of *Anacardium occidentale* dye extract



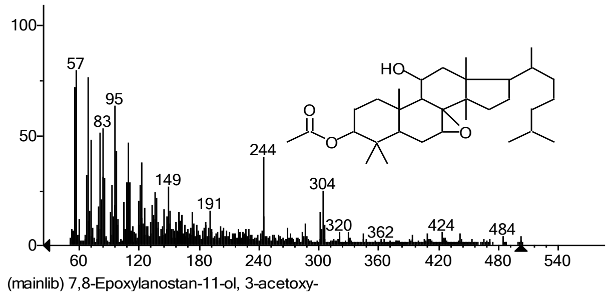


Fig. 12: MS fragmentation of *Anacardium occidentale* dye extract

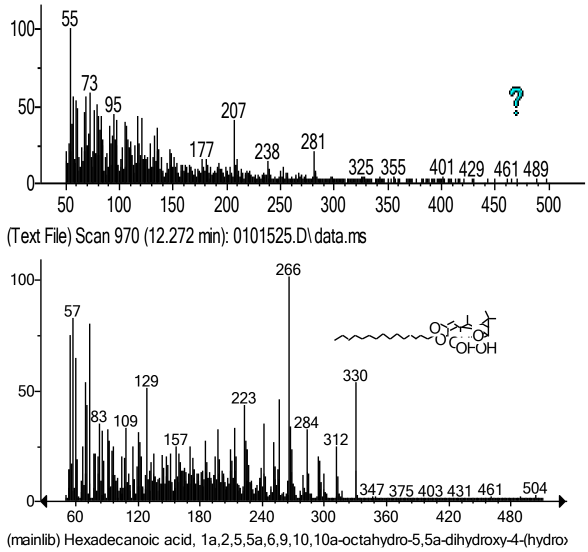


Fig. 13: MS fragmentation of *Anacardium occidentale* dye extract

Conclusion

The study carried out on characterization of dye extracts of Cashew (*Anacardium occidental*) fruit juice revealed the presence of compounds with functional groups C=O, C=C, N-H, C-O, C-H. These functional groups are considered to be responsible for colour characteristics of the dye extracts. The structural characteristics corresponded to the compounds N.N-Dimethyl-o-(1-methyl-butyl-)hydroxylamine and 2,4,7,14-Tetramethyl-4-vinyl-tricyclo(5,4,3,o(1.8))tetradecan-6-ol and N,N'-Bis(Carbobenzyloxy)-lysinemethyl(ester), Tetra acetyl-d-xylonic nitril, Methanocyclopenta(a)cyclopropa(e)cyclodecen-11-one, 7,8-Epoxylano stan-11-ol, 3-acetoxy- and Hexadecanoic acid. Therefore, the dye extract was ascribed to belong to the family of anthocyanins. The interaction between these substances with cellulosic materials could be the reason for the formation of strong bonds of dye-cellulose, difficult to break by common surfactants thereby creating a near permanent stain on the material.

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Conflict of Interest

Authors have declared that no competing interests exist.

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