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Extraction and Characterization of Natural Dyestuffs from Onion (*Allium Cepa)* Bulb, Carrot *(Daucuscarota*l.*)* Root and Turmeric *(Curcuma Longa)* Root

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Abstract- Extraction and Characterization of Natural Dyestuffs from onion (Allium cepa), carrot (DaucuscarotaL.) and Turmeric (Curcuma longa), were studied to access the physical properties and the spectral features of the natural dyestuffs from onion, carrot and turmeric using ethanol as the solvent for extraction of the dyestuffs. The dyestuffs obtained gave different colours of dark tan, dark red and dark orange and percentage yields of 5.00% 11.10% and 16.00% for onion, carrot and turmeric respectively. They were subjected to other physical analysis like melting point, solubility, and pH determination. From the physical analysis, the melting point obtained were 26°C - onion, and 34°C - carrot 46°C - turmeric. The solubility test showed that onion was insoluble in cold water but soluble in hot water, carrot was soluble in cold water while turmeric was sparingly soluble in cold water and readily soluble in hot water. The pH values of the dyestuffs falls in the range of 4.04 for onion, 4.57 for carrot and 5.25 for turmeric which are indicative of acidic components in each extracted dyestuffs.Spectroscopic analyses were also carried out and it was observed that all the dyestuffs absorb at the visible region and results obtained also showed that onion, carrot and turmeric have a wavelength of maximum absorption at 400nm, 400nm, and 420nm respectively which are indicative of the presence of conjugated bonds and chromophores in each dye extract. Fourier Transformed Infra-Red (FTIR) spectroscopic analyses were also carried out on the dye stuff and the results showed various peaks with IR frequencies. The peaks at 3288 cm^{-1}, 3257 cm^{-1}, and 3339 cm^{-1} for onion, carrot and turmeric respectively is an indicative of the presence of O-H stretch, H-bonded of alcohol/phenol in the dyestuffs. The peaks at 1640 cm^{-1}, 1636 cm^{-1}, and 1677 cm^{-1} are indicative of the -C=C- stretch of conjugated alkene/ ketone. And the peaks at 1408 cm^{-1}, 1408 cm^{-1} and 1580 cm^{-1} for onion, carrot and turmeric dye extracts respectively are indicative of -C-C- stretch in rings (aromatics). The peaks at 1777 cm^{-1} and 1710 cm^{-1} for onion and carrot are indicative of presence of C=O stretch of carbonyl group/carboxylic acids. These spectral features relate to the main quality attributes of the three dyestuffs that can be determined using infrared spectroscopy. Based on obtained results, it can be concluded that the quality parameters of the natural dyestuffs from onion(Allium cepa),carrot (DaucuscarotaL.) and turmeric(Curcuma longa) can be predicted based on spectral features.

Indexed Terms- dyestuffs, extraction, characterization, onion (allium cepa), carrot (daucuscarotal.), turmeric (curcuma longa)

I. INTRODUCTION

Reactive dyes are extensively utilized in the textile industry due to their wide variety of color shades, simplicity of application, high wet fastness profiles, brilliant colors, and minimal energy consumption (Alenka*et al.*, 2008). Owing to their wide range of bright shades and enhanced colour fastness properties, synthetic dyes have been widely employed in textile industries as compared to natural dyes (Naveed*et al.,* 2020). However, there are environmental concerns about the unchecked use of synthetic dyes in the textile industry as they are associated with water pollution and several environmental harzards(Alenka*et al.,* 2008). In recent times, natural dyes are receiving wide acceptance in the field of textile coloration. Environmentally speaking, they are more desirable than synthetic dyes because they are eco-friendly, non-toxic, non-allergenic and biodegradable (Egbujor*et al.,* 2019,Nurunnesa*et al.,* 2018).The synthetic dyes produce skin allergies, toxic wastes and other harms to human body and cause environmental hazards (Bruno *et al.,* 2019). The above effects initiated the research line for this work and the need to focus on the development of new dye source and rapid methods for the effective dyeing with onion (*Allium cepa)* bulb, carrot (*Daucuscarota*L.), and turmeric (*Curcuma longa)* roots. The aim of this study was to carry out the extraction and characterization of the Dye Stuff from onions (*Allium cepa)* bulb, carrot (*Daucuscarota*L.) and turmeric (*Curcuma longa*) roots.

II. MATERIALS AND METHODS

2.1 Materials

Onion (*Allium cepa*) bulb, Carrot (*Daucuscarota*L*)* roots and Turmeric (*Curcuma longa*) roots. These materials were obtained fromMayor Market in Agbani Road, Enugu State, Nigeria. Reagents such as ethanol, deionized water, pH 4 buffer solution, potassium bromide were used. All the chemicals used were of analytical grade and were used without further purification.Equipment/Apparatus include

Schimadzu model 1800 double beam UV-VIS spectrophotometer with spectral bandwidth of 1.8nm, wavelength accuracy of 2nm and a pair of 1 cm matched quartz cells of 10mm optical path length was used for all absorbance measurement. Shimadzu 8400s Fourier Transform Infrared (FT-IR) spectrophotometer was used to obtain the infrared spectra and the absorption given in wave number (cm^{-1}).

2.2 Methods

2.2.1 Sample Preparation of the Dye-Stuff Extracts

The onion (*Allium cepa*) bulb, carrot (*Daucuscarota*L.) and turmeric (*Curcuma longa*) roots, were bought and thoroughly washed with clean water to remove any impurities. The samples were further reduced to smaller sizes and were dried under the sun. The samples were then ground to fine powder to allow for most intimatecontact with solvent (Egbujor, *et al.,* 2019).

2.2.2 Extraction of Dye-Stuff from Onion (*Allium cepa)* Bulb, Carrot *(Daucuscarota* L.*)* and Turmeric (*Curcuma longa)* Roots.

The extraction was performed using the Soxhlet method of extraction.

Measured quantities of pulverized samples (10g) were wrapped in a calico material placed inside the thimble of the Soxhlet extractor. 250 mL of absolute ethanol used as solvent was added to a round bottom flask, which was attached to a Soxhlet extractor and condenser on an isomantle. The crushed plant material is loaded into the thimble of the Soxhlet extractor. The side arm is lagged with glass wool. The solvent was heated using the isomantle, which evaporates, moving through the apparatus to the condenser. In other words, the Soxhlet extraction process heats the solvent (ethanol) to boiling temperature (>78°C) and the evaporated ethanol was contained within the apparatus by the condenser unit. The condensate then drips into the reservoir containing the thimble. Once the level of solvent reaches the siphon it pours back into the flask and the cycle begins again. The extraction of the dyestuffs were refluxed for 3 hrs. The extract phases generated through several operations of the extraction process were first distilled to recover parts of the solvent before evaporating to dryness to obtain the crude solid dye stuff extracts using a water bath. The crude dye stuff extracts were further air dried at ambient temperature to obtain purified dye samples used for the physical and chemical analysis(Redfern *et al.,* 2014, Okenwa-Ani*et al* 2020).

2.2.3 Physical Analysis of the Dyestuff from Onion (*Allium cepa)* Bulb, *Carrot (Daucuscarota*L.*)* and *Turmeric (Curcuma longa)* Roots

The following physical analysis parameters were carried out on the purified dye stuff extracts; (i)Percentage yield, (ii) pH value, (iii)Melting point, (iv)Solubility test and (v)Colour

2.2.3.1 Percentage Yield of the Dye Stuff Extracts

The percentage yield is defined as the percentage of the product obtained compared to the theoretical maximum (predicted) yield calculated. This was determined after obtaining the sample weight and dye extract weight in each case using the formula;

$$\text{Percentage yield} = \frac{\text{weight of sample} - \text{weight of extract}}{\text{Weight of sample}} \times 100$$

2.2.3.2 pH Determination of Dye Stuff Extracts

Measuredquantities of the dye stuff in each case was weighed into a 100mL beaker and 20mL of deionized water was added which was then placed on a stirrer to mix for few minutes. The mixture was allowed to stand for 10 mins. Both the buffer and the dye sample were allowed to come to room temperature. The pH tester was calibrated with a pH 4 buffer solution. The electrode and automatic temperature compensation (ATC) were rinsed with deionized water and then blot dry. The probe was placed in the dye sample solution and the pH was measured and recorded.

2.2.3.3 Melting Point Determination of the Dye Stuff Extracts.

The dye stuff in each case were fed into a thin-walled capillary tubes sealed at one end. To pack the tube, the open end was pressed into a small amount of the dye stuff on a weighing paper. The dye stuff was transferred from the open end of the tube to the bottom of the tube by gently tapping the bottom of the tube. The capillary tube and the thermometer was placed in a melting point apparatus and the melting process was observed through the magnifying lens of the apparatus.

2.2.3.4 Solubility Test of Dye Stuff Extracts

The solubility tests of the dye stuff in 1 ml portion of cold and warm water were carried out using 0.1 g of the dye stuff in each case.

2.2.3.5 Colour of the Dye Stuff Extracts

The colour of the dye stuff were determined by ordinary physical observation. The dye stuff have different colour and this is very helpful in the classification of the dye stuff since no two dye stuff in this research had the same colour.

2.2.4 Spectral Analysis of the Dye stuff from Onion (*Allium cepa)* Bulb,Carrot *(Daucuscarota*L.*)* and Turmeric *(Curcuma longa)* Roots.

2.2.4.1 UV-Vis Spectroscopy Analysis of Dye Stuff Extracts

A diluted aliquot of the dye stuff in each case was introduced in a quartz cell (1cm path length) and was analyzed in a UV/Vis spectrophotometer. A scan from 340 to 700nm was performed in order to generate the characteristic absorption spectra of the sample. The dilution solvent used as the blank was ethanol.

2.2.4.2 FTIR Spectroscopy Analysis of Dye Stuff Extracts

2 mg of powdered dye stuff was mixed thoroughly with 200mg of potassium bromide (KBr) and homogenized in an agate mortar. The mixture was then placed in the sample compartment of Fourier Transformed Infrared Spectrophotometer (FTIR) for analysis.

III. RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 Physical Analysis of Dye Stuff Extracts

Table 1: Results of the Physical Analysis/Properties of Dye Stuff Extracts.

Dyestuff Plant	Yield (%)	pH value	M.pt (ºC)	Solubility		Colour
				Cold water	Hot water	
Onion Bulb	5.00	4.04	26	Insoluble	Soluble	Dark Tan
Carrot root	11.10	4.57	34	Soluble	-	Dark Red
Turmeric root	16.00	5.25	46	Sparingly Soluble	Readily Soluble	Dark Orange

Table 2: UV/Vis Spectral Analysis of the Dye Stuff Extracts

Wavelength (nm)	Absorbance (Onion Dye Stuff)	Absorbance (Carrot Dye Stuff)	Absorbance (Turmeric Dye Stuff)
340	0.4554	0.6409	0.7305
360	0.4794	0.6704	0.7540
380	0.5009	0.6981	0.7899
400	0.5212	0.7172	0.8228
420	0.4241	0.6338	0.8459
440	0.3838	0.5867	0.7047
460	0.3191	0.5507	0.6696
480	0.2334	0.5117	0.6308
500	0.1803	0.4650	0.5854
520	0.1803	0.4025	0.5284

540	0.1521	0.2995	0.4589
560	0.1521	0.2382	0.3784
580	0.1309	0.2219	0.2678
600	0.1309	0.2000	0.2218
620	0.1309	0.1908	0.2080
640	0.1309	0.1908	0.1803
660	0.0969	0.1521	0.1677
680	0.0969	0.1521	0.1521
700	0.0969	0.1521	0.1309

3.1.2 FTIR Spectral Analysis of the Dye Stuffs

Table 3: FT-IR Spectroscopic Data of Onion Dye Stuff

IR Frequency (cm^{-1})	Peak Range (cm^{-1})	Assignment	Functional group
3268	3500-3200	O-H stretch, H-bonded	Hydroxyl group (Alcohol/Phenol)
2885	3000-2800	N-H stretch	Amine
2829	2830-2695	C-H stretch	Aldehyde
1777	1800-1770	C=O stretch	Carbonyl group
1640	1648-1638	-C=C- stretch	Alkene/quinone or conjugated ketone
1408	1440-1395	C-C stretch (in-ring) O-H bending	aromatics alcohol/carboxylic acids
1341	1420-1330	C-N Stretch O-H bend	secondary amine Alcohol
1248	1275-1200	C-O stretch	Carboxylic acids
1051	1085-1050	C-O stretch	Primary alcohols

		-C-C stretch, ethers	
920	950-910	C=C stretch O-H bend	Alkene Carboxylic acids
864	900-700	C-H bend	Aromatics
816	840-790	C=C bend	Alkene

Table 4: FTIR Spectroscopic Data of Carrot Dye Stuff

IR Frequency (cm^{-1})	Peak range (cm^{-1})	Assignment	Functional group
3257	3500-3200	O-H stretch	Alcohols/phenol
2926	3300-2500	O-H stretch	Carboxylic acid
2855	3000-2850	C-H stretch	Aldehyde
1710	1710-1665	C=O stretch	α, ß- unsaturated aldehydes or ketones
1636	I650-1600	C=C stretch	Conjugated Alkene, Aromatic
1408	1500-1400	C-C stretch (in-ring)	Aromatics
1244	1275-1200	C-O stretch	Alkyl aryl ether
1028	1320-1000 1100-1000	C-O stretch -C-C- stretch	Alcohol, Carboxylic acids, esters, ethers.
916	950-910	C-H stretch O-H bend	Carboxylic acids
816	840-790	C=C bending	alkene

Table 5: FTIR Spectroscopic Data of Turmeric Dye Stuff

IR Frequency (cm^{-1})	Peak range (cm^{-1})	Assignment	Functional group
3339	3500-3200	O-H stretch	Alcohol, phenol

3019	3100-3000	=C-H stretch	Alkenes
2922	3000-2900	C-H stretch	Alkene
1677	1680-1640	-C=C- stretch	Alkene
1580	1600-1580	C-C stretch (in rings)	Aromatics
1531	1600- 1520	C=O stretch or bend	Aromatic/Aliphatics
1431	1440-1395	C=C stretch	Aromatics
1379	1420-1330	O-H bend	Alcohols, phenols
1271	1275-1200	C-O stretch	Alkyl aryl ether
1133	1300-700	Skeletal C-C vibration	-
1028	1320-1000	C-O stretch	Ethers.
961	1000-650	C=C bend =C-H bend	Alkene Alkene
812	840-790	C=C bend	Alkene

3.2 Discussion

In the present study, the extraction and characterization of natural dye stuff from onion *(Allium cepa)* bulb, carrot (*Daucuscarota* L.*)* and turmeric (*Curcuma longa*) roots were investigated. The method involved exploring some of the physical and spectroscopic properties of the dye stuff extracts prepared from onion bulb, carrot and turmeric roots. The essence of applying spectroscopic analysis on the dye stuff extracts obtained was to non-invasively assess and predict the various quality characteristics of the dye stuff extracts (Ahmed *et al*., 2018) as well as the quantitative analysis of the dye stuff extracts. The method of extraction used for the extraction of dye stuff from Onion bulb, Carrot and Turmeric roots was the Soxhlet extraction method using ethanol as solvent and the essence of choosing the method over other extraction methods as stated in literature was to minimize the amount of solvent used and also reduce cost since in this method, solvent used can be reused. Because aromatic molecules are powerful chromophores in the UV/Vis range, spectroscopic analysis involving UV/Vis and IR were used for the quantitative analysis of the dye stuff extract. Extraction of dye stuff from onion bulb was used in this investigation as opposed to the extraction of dye stuff from onion skin as reported in most literature reviewed (Seema 2017). This was considered in order to ascertain if onion bulb dye stuff will show similar characteristics (physical and spectral properties) as the dye stuff from onion skin.

3.2.1 Extraction and Characterization of the Natural Dye Stuff from Onion *(Allium cepa)* Bulb, Carrot (*Daucuscarota* L.*)* and Turmeric (*Curcuma longa*) Roots

3.2.1.1 Physical Measurement

The crude dye stuff prepared from onion (*Allium cepa*) bulb, carrot (*Daucuscarota*L.*)*and turmeric (*Curcuma longa*) roots were further analyzed to determine some of the physical properties of the dye stuff in each case. The results of the physical analysis of the investigated dye stuff from onion *(Allium cepa)* bulb, carrot

(*Daucuscarota* L.*)* and turmeric (*Curcuma longa*) roots have been presented above.These physical properties of the dye stuff extracts are inclusive of percentage yield, pH value, melting point, solubility and colour presented in table 1.Crude extract is the quantity of the dye stuff extracted from the original sample of the individual plants to be analyzed.

3.2.1.2 Percentage Yield
In the course of the study, the quantity of the dye stuff produced from 10g of onion (*Allium cepa*) bulb, carrot (*Daucuscarota*L.*)* and turmeric (*Curcuma longa*) roots were 0.5g, 1.11g and 1.6g respectively. Table 1 showed that the amount of dye stuff produced from the 10g of onion bulb, carrot and turmeric roots were relatively low. But the higher % yield for turmeric dye stuff over onion and carrot dye stuff is indicative that the solvent (ethanol) used in extraction have more affinity for turmeric dye stuff as opposed to the other dye stuff extracts. The affinity of extraction dyes for the solvent is dependent on the chemical structure of dye and the polarity (Soheil 2017).

The percentage yield of the dye stuff in each case was calculated per 10g of the respective samples

3.2.1.3 pH Value
The pH values of the dye stuff extracts were obtained as shown intable 1.. The dye stuff from onion bulb, carrot and turmeric roots gave a pH value of 4.04, 4.57 and 5.25 respectively. The pH values gathered, showed that the three dye stuff extracts are acidic in nature as all the values are in the left hand side of the pH scale. Also, comparing the three dye stuff extracts, it can be observed that onions dye stuff which had the value of 4.04 was more acidic compared to the other dye stuff extracts.

3.2.1.4 Melting Point
The melting point of a compound is the temperature at which it changes from a solid to a liquid. At the melting point, the solid and liquid phase exist in equilibrium. This is a physical properties often used to identify compounds or to check the purity of a compound. Melting point of the dye stuff from onion bulb, carrot and turmeric roots was another vital physical property of the dye stuff extracts that was determined as shown in table 1. The melting point results obtained. From the results obtained, dye stuff from onion bulb had a melting point of 26^{o}C, dye stuff from carrot roots had a melting point of 34^{o}C and dye stuff from turmeric roots had a melting point of 46^{o}C.

3.2.1.5 Solubility
Solubility is the ability of a solid, liquid, or gaseous chemical substance (referred to as the *solute*) to dissolve in *solvent* (usually a liquid) and form a *solution*. The solubility of the dye stuff extracts were also determined and from the results obtained as shown in table 1, it was observed that dye stuff from onion bulb was insoluble in cold water but soluble in hot water. Dye stuff from carrot was soluble in cold water while the dye stuff from turmeric was sparingly soluble in cold water but was readily soluble in hot water.

3.2.1.6 Colour
Another physical analysis carried out in the course of the investigation was determination of the physical colours of the dye stuff extracts. As represented in table 1 was observed that the dye stuff from onion bulb had a Dark tan colour, dye stuff from carrot root had a dark-red colour and dye stuff from turmeric root had a dark-orange colour.

3.2.2 UV/Vis Spectroscopic Analysis of Natural Dye Stuff from Onion *(Allium, cepa)* Bulb, Carrot (*Daucuscarota* L.*)* and Turmeric (*Curcuma longa*) Roots.
Table 2 showed the results of the UV/Vis spectral analysis of onion *(Allium cepa)* bulb, carrot (*Daucuscarota* L.*)* and turmeric (*Curcuma longa*) roots. From the results obtained, extraction of onion bulb, carrot and turmeric roots using ethanol as extraction solvent gave dye stuff extracts that showed highest absorption peak at 400 nm, 400nm and 420 nm respectively. This results showed that there was strong absorption of the visible light by the three dye stuff extracts under investigation. This may be indicative of the presence of conjugated bonds in the dye stuff extracts. In other words, the dye stuff extracts contained series of functional groups, which are chromophores that produce light absorbance in the visible region (Ogboso, 2006).

3.2.2.1 FTIR Spectroscopic Analysis of Natural Dye Stuff from Onion *(Allium cepa)* Bulbs, Carrots (*Daucuscarota* L.*)* and Turmeric (*Curcuma longa*) Roots.

The FTIR spectral analysis results of the natural dye stuff from onion *(Allium cepa)* bulb, carrot (*Daucuscarota* L.*)* and turmeric (*Curcuma longa*) roots are presented in Table 3, 4 and 5 respectively. From the results, the dye stuff extracts contained series of functional groups, which are chromophores that produce light absorbance in the visible region (Ogboso, 2006).

3.2.2.2 FTIR Spectral Analysis of Dye Stuff from Onion Bulb

The most important IR bands and assignments of dye stuff from onion are given in table 2. As shown in table 3, the IR spectrum of onion dye stuff showed peak at 3268 cm^{-1} and 1408 cm^{-1} which are indicative of the stretching vibration of O-H (hydroxyl group) of phenol and the O-H bending vibration of carboxylic acid respectively. These peaks are indicative of the presence of carboxylic acids confirming the report of Galdon *et al.* (2008) that carboxylic acid is a major organic acid content of onions. Onion contains large quantity of carboxylic acids such as citric acid 48.5%, malic acid 43.6%, tartaric acid 18.8% and oxalic acid 11.3% (Galdon *et al.*, 2008). The peak at 2885 cm^{-1} is due to the stretching vibration of N-H of amino group and it could be attributed to the presence of amino acids in onions (Ifesan, 2017). The peak at 2829 cm^{-1} is due to the C-H stretching of aldehydes as aldehydes had been found to constitute 15 out of the 23 volatile organic compounds (VOCs) in onions (Cecchi *et al.*, 2020). The peak at 1777 cm^{-1} is due to stretching vibration of C=O of esters. 2 out of the 23 VOCs in onions are esters (Cecchi *et al.*, 2020). The peak at 1248 cm^{-1} was due to C-O stretching of carboxylic acid. Also, the peak at 1051 cm^{-1} was due to the C-O stretching of alcohols. 1 out of the 23 VOCs in onions is alcohol (Cecchi *et al.*, 2020). Table 2 also displayed absorption bands at at 920 cm^{-1}, 816 cm^{-1}, 775 cm^{-1} which corresponds to the stretching vibration of C=C of the phenyl group in onion. Onions have a high phenolic content (Ashish*et al.*, 2013).

3.2.2.3 FTIR Spectral Analysis of Dye Stuff from Carrot *(Daucuscarota* L*)* Root

The most important IR bands and assignments of dye stuff from carrot are given in table 4. As shown in table 4, the IR spectrum of carrot dye stuff showed peak at 3257 cm^{-1} and 2926 cm^{-1} which was indicative of the stretching vibration of O-H of phenol and O-H stretch of carboxylic acids. These peaks are indicative of the presence of phenolic acids confirming the report of Sharma *et al.* (2012) that phenolic acids are present in carrot roots. Carrot root provides 54.1% of the amount of total phenolic while the phloem tissue provides 39.5% and the xylem tissue provides only 6.4% (Sharma *et al.*, 2012). The peak at 2855 cm^{-1} and 1710 cm^{-1} was due to the C-H stretching of aldehydes and stretching vibration of C=O of unsaturated aldehyde or ketone. According to Guler*et al.* (2015) VOCs identified in carrots are classified into three main chemical classes which are inclusive aldehydes, monoterpenes and sequiterpenes. Only a few volatiles were detected in other chemical classes such as ketones, polypropanoids and alcohols. 12 VOCs out of the 17-31 VOCs in carrot include, aldehyde, alcohol etc and these 12 VOCs may be characteristics for carrot flavor. (Guler*et al.*, 2015). As reported by Sharma *et al.* (2012), the edible portion of carrots contains about 10% carbohydrates. The peak at 1636 cm^{-1} was due to C=C stretch of conjugated alkene/aromatics which was indicative of the presence of carotene in carrot which may be characteristics for carrot colour. Also, the peak at 1408 cm^{-1} may be attributed to the C-C stretch in aromatic rings. The absorption bands at 1244 cm^{-1} and 1028 cm^{-1} was due to C-O stretch of alkyl aryl ether and C-O stretch of carboxylic acids/alcohol respectively. 1 out of the 12 VOCs in carrot is alcohol (Guler*et al*. 2015). Table 4 also displayed absorption bands at at 916 cm^{-1}, 816 cm^{-1}, which corresponds to the stretching vibration of C=C of the phenyl group in carrot. Carrot root have a significant amount of phenolic content (Sharma *et al*., 2012). Phenolics in carrots are present throughout the roots but are highly concentrated in the periderm tissue. The phenolic compounds in carrot as reported by Sharma *et al*. (2012) to contain mainly hydroxycinnamic acids and para-hydrobenzoic acid.

3.2.2.4 FTIR Spectral Analysis of Dye Stuff from Turmeric Root

The most important IR bands and assignments of dye stuff from turmeric root are given in table 5. As shown in table 5, the IR spectrum of turmeric dye stuff showed peak at 3339 cm^{-1} and 1431 cm^{-1} are indicative of the stretching vibration of O-H of hydroxyl group (phenol) and the O-H bending vibration of carboxylic acid respectively. These peaks are indicative of the presence of polyphenolic compounds in turmeric rhizome confirming that Curcumoids (3-6%) are major polyphenolic compounds in turmeric. Turmeric contains some quantity of Curcumin, demethoxycurcumin and bisdemethoxycurcumin collectively known as curcumoids which is about 3-6%. The presence of curcumin was indicative of the characteristic colour of turmeric dye stuff.

The peak at 3019 cm^{-1} is due to the stretching vibration of =C-H of alkene and it could be attributed to the presence of conjugated bond in the turmeric structure (Javad*et al.*, 2020). The peak at 2922 cm^{-1}, 1677 cm^{-1} are due to the C-H stretching of alkene and C=O stretch of conjugated ketone. (Javad*et al.*, 2020). The peak at 1580 cm^{-1} is due to stretching vibration of C-C in aromatic rings. These peaks are indicative of the structural characteristics of curcumin. According to Priyadarsini, (2014) curcumin has three chemical entities in its structure: two aromatic ring systems containing o-methoxy phenolic group. Also, the high intensity band at 1513 cm^{-1} was due to the mixed vibrations including stretching carbonyl vibration v(C=O), in plane bending vibrations around aliphatic and aromatic of enol and keto configuration of curcumin (Ismail *et al.*, 2014). The peak at 1271 cm^{-1} and 1028 cm^{-1} was due to C-O stretching of alkyl aryl ether. Table 8 also displayed absorption bands at at 961 cm^{-1}, 812 cm^{-1} which corresponds to the bending vibration of C=C of alkene group in turmeric.

CONCLUSION

This research has to an extent demonstrated the use of plants such as onion *(Allium cepa)*, carrot *(Daucuscarota* L.*)* and turmeric *(Curcuma longa)* as sources of dyes for various applications. Extraction and purification of the dyes were by soxhlet extraction and evapouration of solvent used respectively. The percentage dye yield of the plants was also below average. Therefore from these results obtained, it is very obvious that industries mostly using dyes cannot absolutely rely on natural dyes for finishing, this is, as a result of the poor percentage yield of these dyes. But can complement the available synthetic dyes with natural dyes.From the UV-visible spectra results of the dye stuff obtained, the dye stuff extracts absorbed strongly in the UV-Vis region. In other words, the dye stuff extracts are organic compounds. The possible colours that could be obtained from the individual plant dye stuff are Dark Tan from onion *(Allium cepa)* bulb, Dark red from carrot *(Daucuscarota)* root and Dark orange from turmeric *(Curcuma longa)*. Although these extracts have the above mentioned visible colours, these colours can also be altered during application (dyeing) by the use of different mordants. The infra-red spectra of the dye stuff extracts confirmed the presence of chromophores such as COOH, OH, CO, N-H, -C-H, C-C and –C-NH, C=C, =C-H, etc. in the extracted dyes, which account for the coloured nature of the dye stuff extracts. In other words, the dye stuff extracts are not just tannins but dyes that could be used in the leather, textile and food industries. The results obtained showed that the dye stuff extracts are aromatic in nature with groups such as hydroxyl group (OH) in the phenolic group,but the number and the position of the hydroxyl groups present in each of the dye stuff extracts could not be established.From the results of the various assessments conducted, it is established that dyes from onion *(Allium cepa)* bulb, carrot *(Daucuscarota)* and turmeric *(Curcuma longa)* are 100 percent toxic free and can therefore be recommended for industrial use aside the use of synthetic dyes.

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