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Research Article

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The effect of solvent polarity using water, n-hexane and methanol on the extraction of turmeric rhizome and its application on cotton fiber.

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Abstract

Curcumin, owing to its numerous therapeutic activities is on high demand and has great market potential, high cost. Since curcumin has diverse applications, extracting it in a less expensive method other than super critical fluid extraction is the main aim or objective of this work. This project work mainly deals with the extraction and characterization of curcumin from its common source turmeric rhizome using three different solvents of varying polarity. It was evident that for turmeric plant rhizome the polarity of the solvent used for extraction determines the quantity of yield that will be obtained. The polar solvent tends to give higher yield than the non-polar solvent.

1.0 Introduction

The turmeric (*Curcuma longa*) plant, is a perennial medicinal plant of the ginger family, cultivated extensively in the south and southeast tropical Asia, especially in India where it is commonly called ‘Haldi’. Turmeric has been valued worldwide as a functional food owing to the discovery that its rhizome powder which when introduced to food, preserves its freshness and imparts a characteristic flavour (Nelson *et al.*, 2017). This rhizome is also referred to as the root and is the most useful part of the plant for culinary and medicinal purposes. Turmeric gets its characteristic yellow colouration from its curcuminoids content which was first isolated by Vogel in 1842 (Priyadarsini, 2014). Curcumin the most important component of turmeric is an orange-yellow crystalline powder practically insoluble in water. The structure of curcumin

($C_{21}H_{20}O_6$) was first described in 1910 by Lampe and Milobedeska and has been proven to be diferuloylmethane (Priyadarsini, 2014).

Scientific research spanning over more than four decades has confirmed the diverse pharmacological effects of curcumin and established its ability to act as a chemopreventive agent as well as a potential therapeutic agent against several chronic diseases (Nelson *et al.,* 201; Shanmugam *et al.,* 2015). Curcumin, having almost two centuries old scientific history, is still attracting researchers from all over the world. While the majority of researchers have been pursuing the biological aspects, a few others were interested in understanding the important chemistry of curcumin behind its unique biological activity. Curcumin research has become one of the most favourite subjects for all the branches of chemistry, including organic, inorganic, physical and analytical chemists. Inorganic chemistry the extraction and synthesis of curcumin and new synthetic derivatives were the main focus of research (Priyadarsini, 2014).

Although extraction and separation of curcumin from turmeric powder was reported way back in 1815, more improved and advanced extraction methods are still being reported, even after two centuries (Kurmudle *et al.*, 2013; Takenaka *et al.*, 2013). Solvent extraction followed by column chromatography has been the most commonly employed method reported for separating curcumin from turmeric, and several polar and non-polar organic solvents have been used, including hexane, ethyl acetate, acetone, methanol, etc (Patil, *et al.,* 2011; Paulucci *et al.*,2013; Li *et al.,* 2014). Of the organic solvents employed, ethanol is the most preferred solvent for extracting curcumin. Although, chlorinated solvents extract curcumin very efficiently from turmeric, they are not commonly employed due to their non-acceptability in the food industry. Soxhlet extraction, ultrasonic extraction, microwave, zone-refining and dipping methods have been applied, and among these the Soxhlet, ultrasonic and microwave extractions are the most commonly employed methods (Anamika, 2012; Vasimalai *et al.,* 2018; Wilken, 2011).The study reports the the effect of solvent polarity on the extraction of turmeric rhizome and its application as dye on cotton fibers using three different solvents: water, n-hexane and methanol.

2.0 Materials and Methods

2.1 Materials

All chemical reagents used in this study where obtained analar grade from a commercial vendor and no further purification carried out. Hexane (JHD, 99 %) and methanol (JHD, 99 %).

2.2 Sample Procurement and Preparation

The sample (turmeric rhizomes) was purchased from Wadata market in Makurdi, Benue state. The turmeric rhizomes were washed with distilled water and then oven dried at 50°C for 72 hours when a constant weight was obtained. The dried turmeric rhizomes were pulverized into fine powders and subjected to particle size separation using a 40,100 and 150µm sieve. The various sized powders were further subjected to solvent extraction by maceration using three different solvents of different polarity: water, n-hexane and methanol. The extracts were subjected to solvent recovery using a rotary evaporator.

2.3 Characterization

The extracts obtained were further subjected to characterization by Ultraviolet-visible spectrophotometer (Jenway 741501, Stone Staffs UK), Fourier transform infrared spectrophotometer(8400SINFRARED Spectrophotometer).

2.4 Dyeing using turmeric powder extract.

5.0 g of turmeric powder (hexane extract) was introduced into a hot distilled water (100), a 24 by 24 fabric material was introduced in to the boiled dye and allowed to stand for 5mins, rinsed and allowed to dry under sun-free weather to get the colour needed. This process was repeated for the methanol and the distilled water extracts.

3.0 Results

3.1 Result presentation

Table 1. FTIR data of n-hexane extract of turmeric plant rhizome

Functional group	Wavelength	Transmittance	Intensity
Water OH stretch	3652.8	89.284	Strong
Alcohol OH stretch and carboxylic group	3257.7	78.280	Strong
-C-H stretch	2922.2	78.949	Weak
C≡C stretch	2113.4 1994.1	88.463 89.769	Variable
C=C alkene	1625.1	74.828	Weak
C=O amide	1580.4	71.585	Strong
C=C aromatic	1427.6	71.127	Weak
NO_2 stretch	1375.4 1271.0 1233.7	76.097 68.836 71.065	Strong
C-OH stretch	112.9	67.832	Strong
C-F stretch	1073.5	67.339	Strong
C-OH stretch	1025.0 857.3 812.6	59.543 72.474 68.941	Strong

Table 2. FTIR data of methanol extract of turmeric plant rhizome

Functional group	Wavelength	Transmittance	Intensity
Alcohol OH stretch	3451.5	92.963	Strong
-C-H stretch	2985.6 2769.4	89.934 89.201	Weak
C≡C stretch	2079.9	89.183	Variable
	1990.4	89.323	
C=O aldehyde	1722.0	81.124	Strong
C=C aromatic	1490.9	90.207	Weak
NO_2 stretch	1330.7	90.794	Strong
C-F stretch	1162.9 998.9 875.9 667.2	71.879 74.608 72.445 82.916	Strong

Table 3. FTIR data of distilled water extract of turmeric plant rhizome

Functional group	Wavelength	Transmittance	Intensity
N-H stretch	327.6	51.097	Strong
=C-H stretch	2929.7	70.372	Weak
C≡C stretch	2105.9	96.299	Variable
C=O amide	1595.3	44.727	Strong
CH_3 bend	1401.5	55.209	Medium
CH_3 bend	1304.6	53.093	Medium
C-O-C stretch	1028.7	26.974	Strong
	924.4	58.107	
	864.7	59.695	
	779.0	45.701	

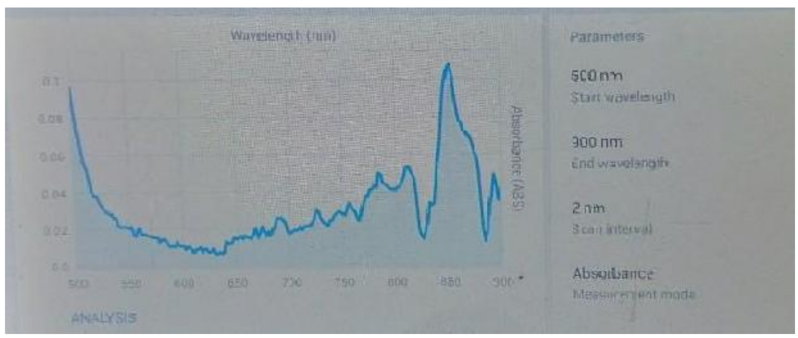

Figure 1. UV spectra for n-hexane extract of turmeric plant rhizome

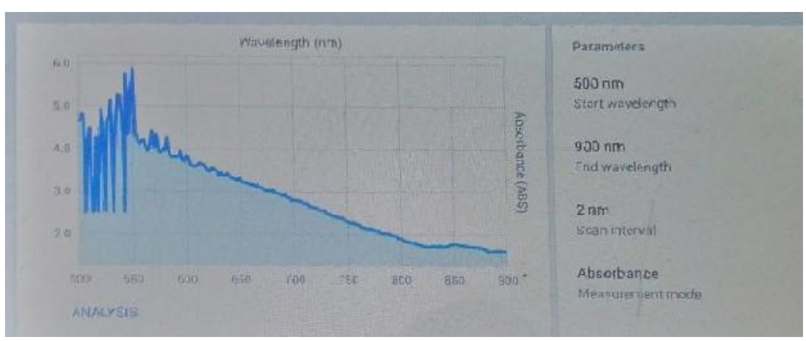

Figure 2. UV spectra for methanol extract of turmeric plant rhizome

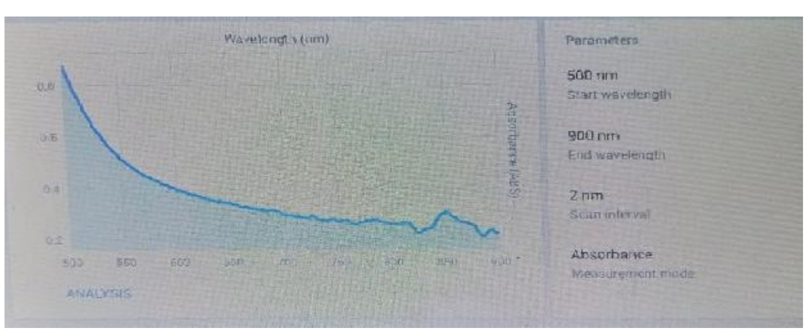

Figure 3.UV spectra for distilled water extract of turmeric plant rhizome

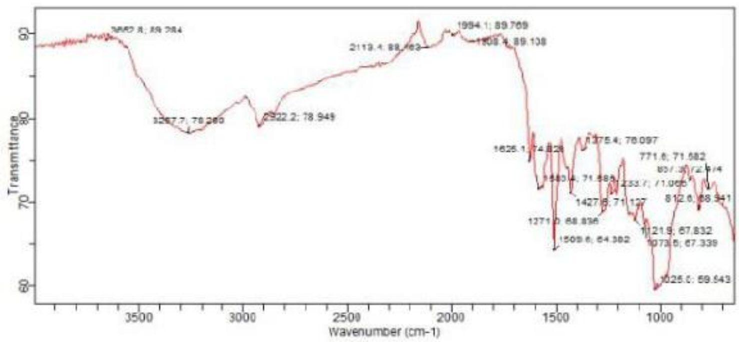

Figure 4. FTIR spectra for n-hexane extract of turmeric plant rhizome.

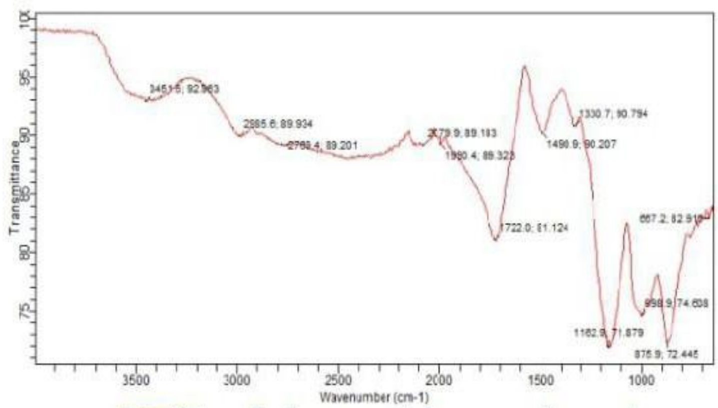

Figure 5. FTIR spectra for methanol extract of turmeric plant rhizome

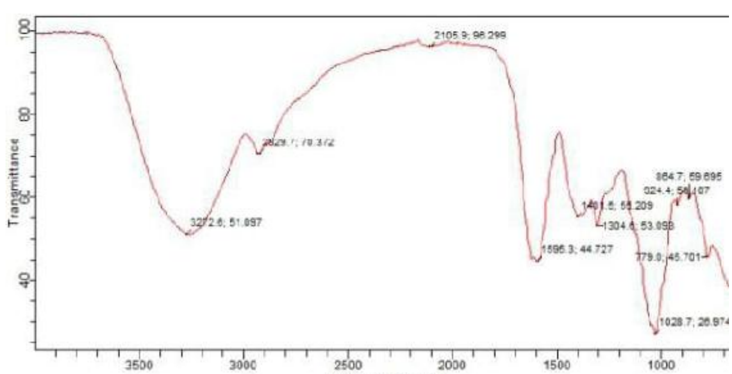

Figure 6. FTIR spectra for distilled water extract of turmeric plant rhizome

3.2 Discussion

Solvents ranging from non-polar to polar ones: n-hexane, methanol and distilled water(H_2O) were used for MAE of turmeric plant rhizomes under the same condition. N-hexane extract has maximum yield of 73.35% While, methanol extract has maximum yield of 86% and water extract has maximum yield of 90.9%. However, the yield of non-polar solvent extract was found to be lowest. This indicates that polar solvents are better for MAE of turmeric plant rhizome. In UV-vis analysis (figure 1, 2 and 3), The sharp peaks for n-hexane, methanol and water extracts were obtained to be 850,550 and 500nm respectively.

This shows their different light intensity base on their polarity.

The FTIR spectrum profile of turmeric plant rhizome (figure 4) shows the absorption bands at 3652.8, 3257.7, 2922.2, 2113.4, 1994.1, 1908.4, 1625.1, 1580.4, 1427.6, 1375.4,1271.0, 1233.7, 112.9, 857.3, 812.6 and 1073.5cm^{-1} are due to the functional groups they represent. The spectrum confirmed the presence of alcohols, alkynes, alkenes, alkyl halides, aromatics, carboxylic compound, nitro compounds and amines in the n-hexane extract.The FTIR spectrum profile of turmeric plant rhizome (figure 5) shows the absorption bands at 3451.5, 2985.6, 2769.4, 2079.9, 1990.4, 1722.0, 1490.9, 1330.7, 1162.9, 998.9, 875.9 and 667.2 are due to the functional groups they represent. The spectrum confirmed the presence of alcohol, alkanes, alkynes, alkyl halides, aromatics, nitro compounds and aldehydes in the methanol extract.The FTIR spectrum profile of turmeric plant rhizome (figure 6) shows the Absorption bands at 327.6, 2929.7, 2105.9, 1595.3, 1401.5, 1304.6, 1028.7,924.4, 864.7 and779.0 are due to the functional groups they represent. The spectrum confirmed the presence of nitro compounds, alkenes, alkynes, amines, carbonyl compounds and alkyls in the water extract.

4.0 Conclusion

From the results, it is evident that for turmeric plant rhizome the polarity of the solvent used for extraction determines the quantity of yield that will be obtained. The polar solvent tends to give higher yield than the non-polar solvent. The UV results proofs that polarity affects the intensity of light. The non-polar extract tends to be more intensify than the polar and the FTIR results confirmed the presence of different functional groups.

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