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Identification of adulterant present in coriander powder using FTIR spectroscopy and chemical method

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Abstract
Coriander is a perennial medicinal herb grown in the tropical regions worldwide. In India, it is used as a potential spice for garnishing and flavoring the dishes and treating several ailments. In Uttar Pradesh, India has a strong aroma similar to the seasonal Coriandrum. But the adulteration in food items is one of the common issues in the present scenario. In connection with this issue, the present investigation was carried out to determine the presence of adulterants in coriander power. Various samples of coriander power (CS1, CS2, CS3, CS4 and CS5) were collected from local market in Kanpur city, Uttar Pradesh. The identification of adulterant in coriander powder samples using chemical methods and Fourier-transform infrared (FTIR) spectroscopy technique was used. The results revealed that the adulteration in most of the coriander powder under investigation. This study was performed to create awareness in the public on the adulteration in ready-made packed coriander powders.

Keywords: FTIR, Coriander samples, food and pharmaceutical industries

1. Introduction

Coriander powder [1], made from ground coriander seeds, is a versatile spice used in various cuisines around the world. Here are some common uses like cooking [2], seasoning, or salads for added flavour, Marinades [3], Baking, Pickling [4], Homemade spice blends, Herbal remedies [5]: In some cultures, coriander powder is used for its purported medicinal properties [6], such as digestion and reducing inflammation [7]. Coriander powder is stored in an airtight container in a cool, dark place to preserve its flavour and aroma [8]. Coriander powder, from a chemical perspective [9], is primarily composed of organic compounds found in coriander seeds. These compounds contribute to its flavour, aroma, and potential health benefits. While the exact composition may vary depending on factors such as the origin and processing of the seeds, some key constituents include: Coriandrum, Linalool, Geraniol [10], Fatty acids, Proteins, Vitamins and Minerals [11]. Adulterants in coriander powder can vary, but some common ones include ground seeds [12] of other plants cheaper seeds from plants like cumin, or fennel may be mixed with coriander powder to increase volume and reduce cost [13]. Sawdust or ground rice [14] these substances may be added to bulk up the weight of the coriander powder. Colouring agents [15] substances like turmeric or artificial colours may be added to enhance the appearance [16] of the powder. Artificial flavourings [17] may be added to mask the taste of inferior quality coriander or other adulterants. To ensure getting pure coriander powder, it's best to purchase it from a trusted source or grind whole coriander seeds. Additionally, checking for certifications or quality seals on the packaging can help to ensure the authenticity of the product [18]. Some common chemical test like phenols, flavonoids, tannins and pH confirm the presence of adulterants. After test the tested sample compared to the standard may indicate adulteration [19]. These tests can provide some indication of adulteration, they may not be conclusive on their own. For a comprehensive analysis, additional tests and methods may be required. The chemical structure of these compounds can vary and may involve complex organic molecules [20] containing carbon, hydrogen, oxygen, and occasionally other elements like nitrogen or sulphur [21]. While coriander powder itself is a mixture of these compounds, individual constituents can be isolated and analysed using techniques like chromatography and spectroscopy. To determine their precise chemical structures [22]. FTIR (Fourier Transform Infrared Spectroscopy) analysis [23] of coriander powder can provide information about the functional groups present in the compounds found in coriander. While the specific peaks observed may vary depending on factors such as the variety of coriander and processing methods. FTIR analysis can provide valuable information about the chemical composition of coriander powder and detect the presence of adulterants based on their unique spectral signatures. In this paper we have discussed some chemical test [24] for testing adulteration in coriander powder using phenols, flavonoids, tannins, pH and FTIR.

2. Materials and Methods

2.1. Materials: Ferric Chloride, Sulphuric acid, Anhydrous $AlCl_3$ (LR Grade).

2.2. Methods

2.2.1. Collections of Samples: Five samples of coriander powder were collected from different grocery shops of Kanpur city, Uttar Pradesh and name them accordingly as CS1, CS2, CS3, CS4 and CS5.

Qualitative test for the detection of adulterants in coriander powder

By using laboratory chemicals we carried out by adapting standard procedure. To test for phenol, flavonoids, tannins and pH in coriander powder, we performed various chemical tests:

2.2.2. Phenol test

On adding concentrate H_2SO_4 and observe the color change. A change in coloration indicated the presence of phenolic group in the coriander sample.

2.2.3. Flavonoid Test

To perform a flavonoid test using $AlCl_3$ and other suitable reagents and observed the color change. The colour change in indicated the presence of flavonoids.

2.2.4. Tannins Test: Tannins can be detected using ferric chloride (FeCl3) solution.

2.2.5. pH Test: The pH of all coriander powder samples is tested by pH strips.

2.2.6. FTIR Analysis

The Fourier Transform Infrared (FTIR) was carried out using a device of type ATR-FTIR mode using the BRUKER ALPHA ll spectrometer with opus software and spectra were solved and plotted through origin 2022b in the range of wavelength of 500 to 4000 cm^{-1}.

3. Result and Discussion

3.1 Adulteration in coriander powder

3.1.1 Phenol Test

In the FTIR spectroscopic analysis, phenolic peaks were observed in all the five samples namely CS1, CS2, CS3, CS4, and CS5 but in the laboratory test CS4 and CS5 showed clearly the presence of phenolic groups but in the chemical test samples of CS1, CS2 and CS3 the presence of phenolic group was not appeared. It may be due to extent of adulteration, variation in the composition and geographical origin etc.

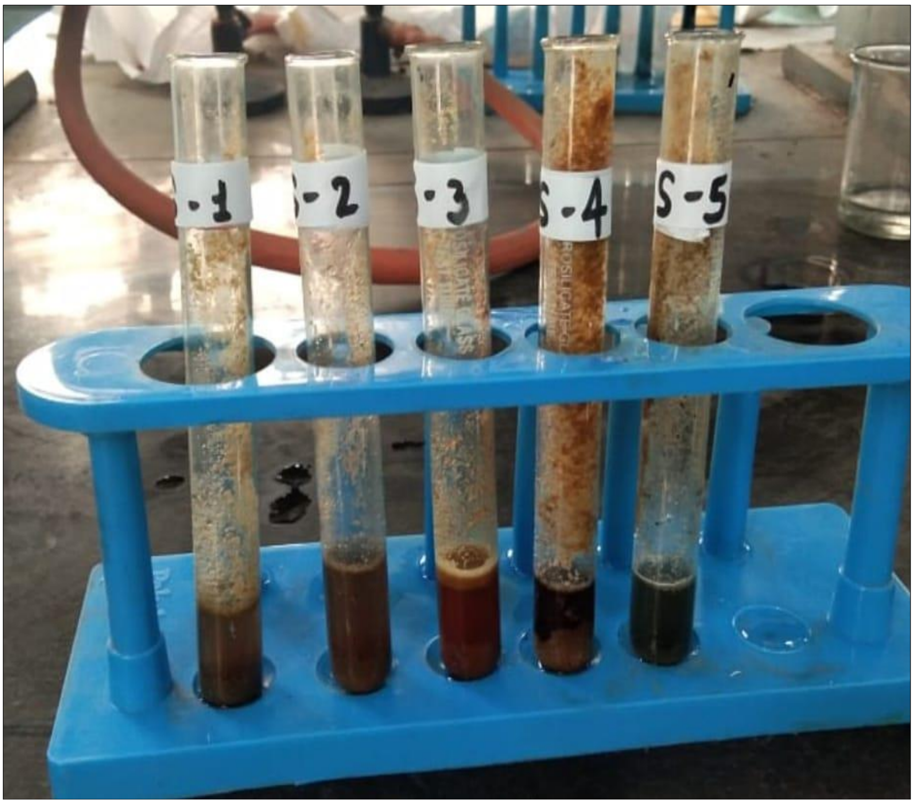

Fig 1: Phenol test in CS1, CS2, CS3, CS4 and CS5 samples

3.1.2. Flavonoids Test: Flavonoids are consistently detected in all samples, as indicated by the FTIR peaks. However, laboratory tests reveal that the presence of flavonoids is notably more pronounced in CS3 and CS4 samples of coriander powder. This disparity in results is attributed to the presence of some adulterants in CS1, CS2, and CS5 samples.

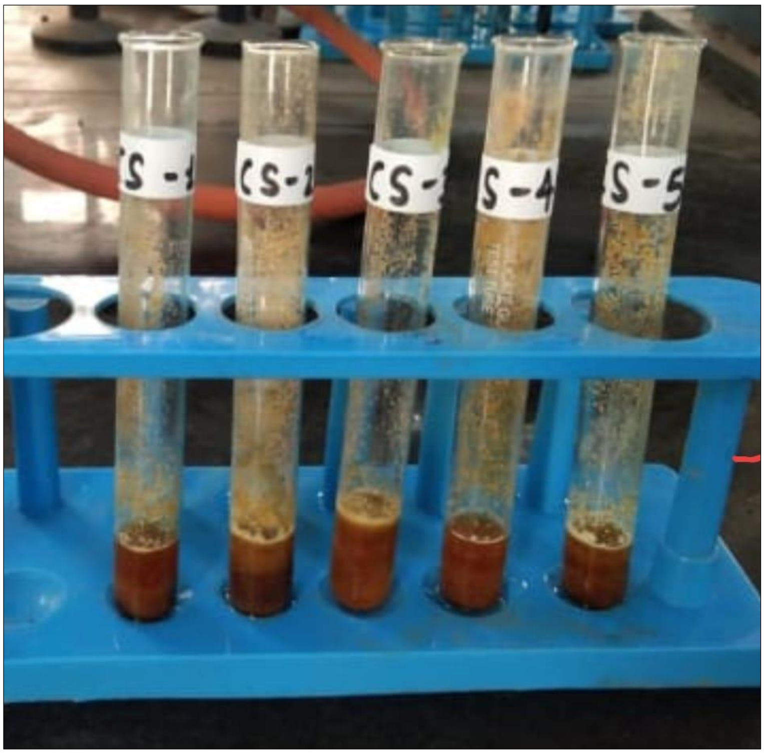

Fig 2: Flavonoids test in CS1, CS2, CS3, CS4 and CS5 samples

3.1.3. Tannins Test
Tannins are detected in all samples of coriander powder, including CS1, CS2, CS4, and CS5. However, this test does not appear in CS3 sample. The absence of the tannin test in the CS3 sample could be indicative of a specific region within the coriander powder batch where tannins are either absent or present in significantly lower concentrations compared to the other samples or some adulterant present in samples.

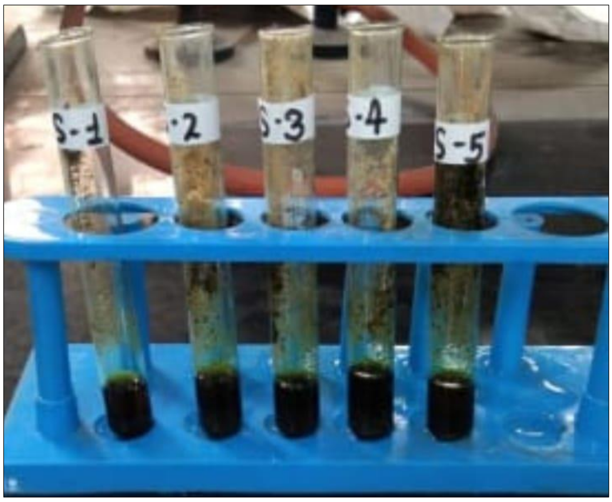

Fig 3: Tannins test in CS1, CS2, CS3, CS4 and CS5 samples.

3.1.4. pH Test: Pure coriander powder generally has a pH ranging from 5.5 to 7, indicating a slightly acidic to neutral nature. It's worth noting that the pH may vary due to factors like the coriander plant's growing conditions, processing techniques employed and the presence of additives or contaminants.

In Figure 4, while all samples display a pH around 8, sample CS3 stands out with a pH of 6. This deviation from the typical pH range for coriander powder raises concerns regarding possible adulteration or contamination with alkaline substances, affecting its taste, aroma, and overall quality. The discrepancy in pH levels among the samples holds several implications.

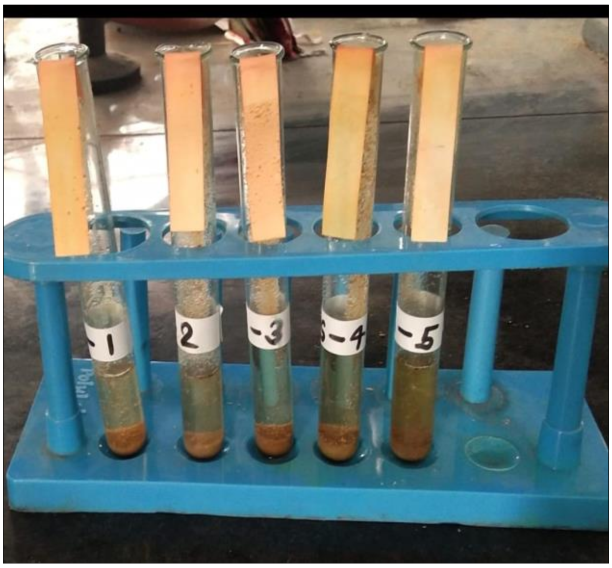

Fig 4: pH test in CS1, CS2, CS3, CS4 and CS5 samples

CS3, with a pH of 6, may offer a slightly or more acidic flavor profile compared to the others having pH 8. This variation in acidity could alter the overall taste experience. Additionally, the pH difference may confer a minor advantage in microbial resistance for CS3, potentially extending its shelf life marginally. Furthermore, pH plays a role in color stability, though the distinction between pH 6 and pH 8 might not significantly impact color characteristics in this context. Finally pH variations can influence chemical reactions within food products, potentially affecting the stability of compounds like antioxidants and essential oils present in coriander powder.

3.1.5. FTIR Analysis

Table 1: FTIR analysis of various samples:

S. No	Functional group	Pure	CS1	CS2	CS3	CS4	CS5
1.	C-H stretching	2923.05-2853.58 cm^{-1}	2922.6 cm^{-1}	2922.3-2855.4 cm^{-1}	2922.69-2856.38 cm^{-1}	2922.78-2856.39 cm^{-1}	2922.79-2856.20 cm^{-1}
2.	C-H stretching	1300-1458.8 cm^{-1}	1449.78cm^{-1}	1451.1 cm^{-1}	1406.43 cm^{-1}	1450.61 cm^{-1}	1408.18 cm^{-1}
3.	C-C stretching	1144.5cm^{-1}	1150.16cm^{-1}	1151.65 cm^{-1}	1149.9 cm^{-1}	1150.69 cm^{-1}	1151.64 cm^{-1}
4.	C=O stretching N-H bending	1744.8cm^{-1}	1709.6-1631.3cm^{-1}	1739.9-1630 cm^{-1}	1711.0-1631.17 cm^{-1}	1709.51-1620.78 cm^{-1}	1710.54-1630.80 cm^{-1}
5.	C-O stretching	1028.75cm^{-1}	1018.5cm^{-1}	1019.3 cm^{-1}	1019.31 cm^{-1}	1021.93 cm^{-1}	1020.35 cm^{-1}
6.	O-H stretching	3302.5 cm^{-1}	3291.0 cm^{-1}	3302.9 cm^{-1}	3290.79 cm^{-1}	3290.9 cm^{-1}	3292.98 cm^{-1}

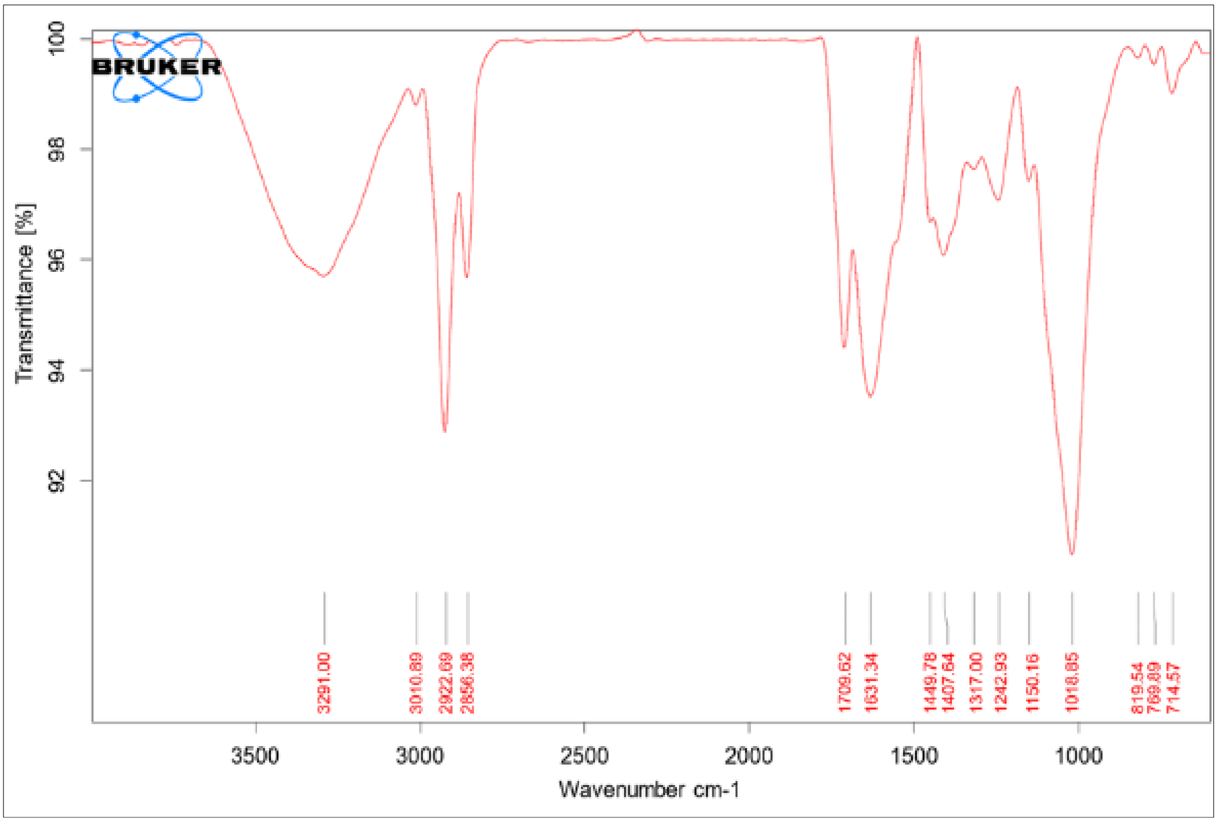

Fig 5: Infrared spectrum of sample CS1

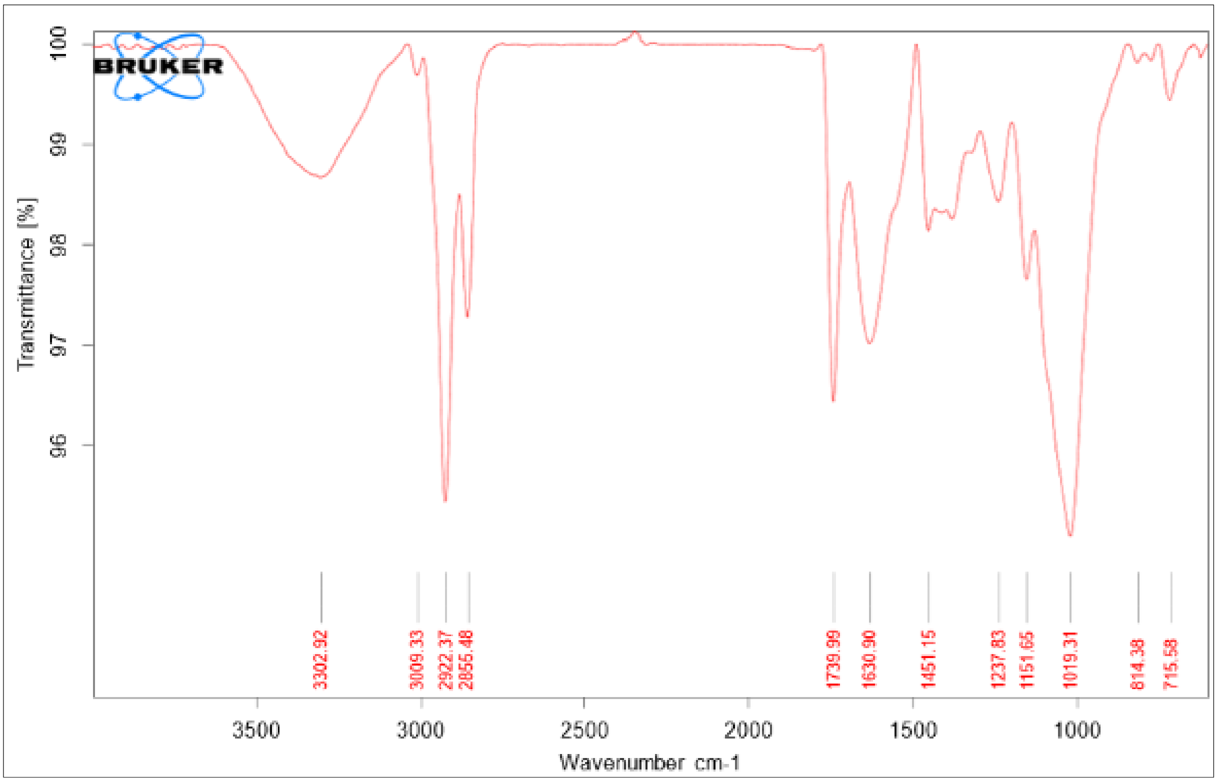

Fig 6: Infrared spectrum of sample CS2

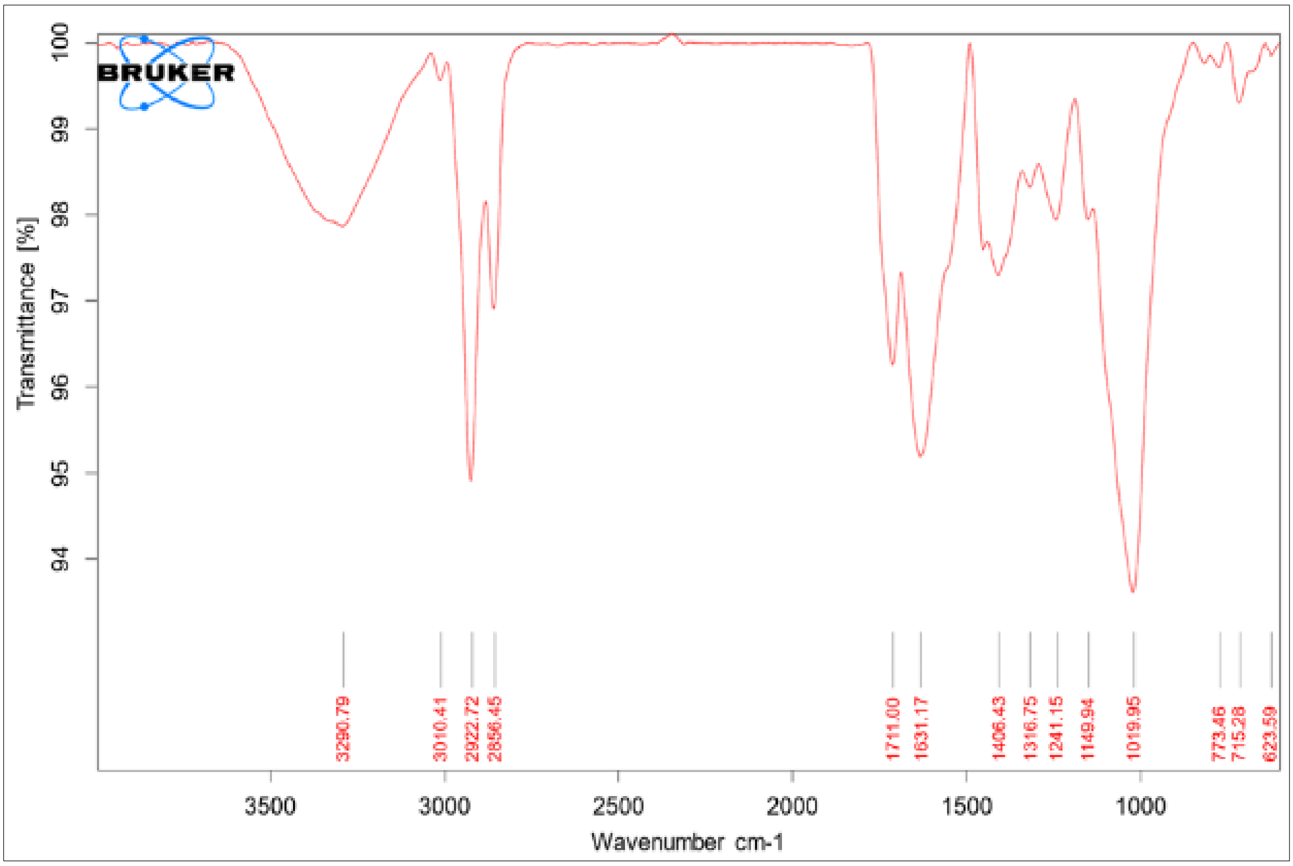

Fig 7: Infrared spectrum of sample CS3

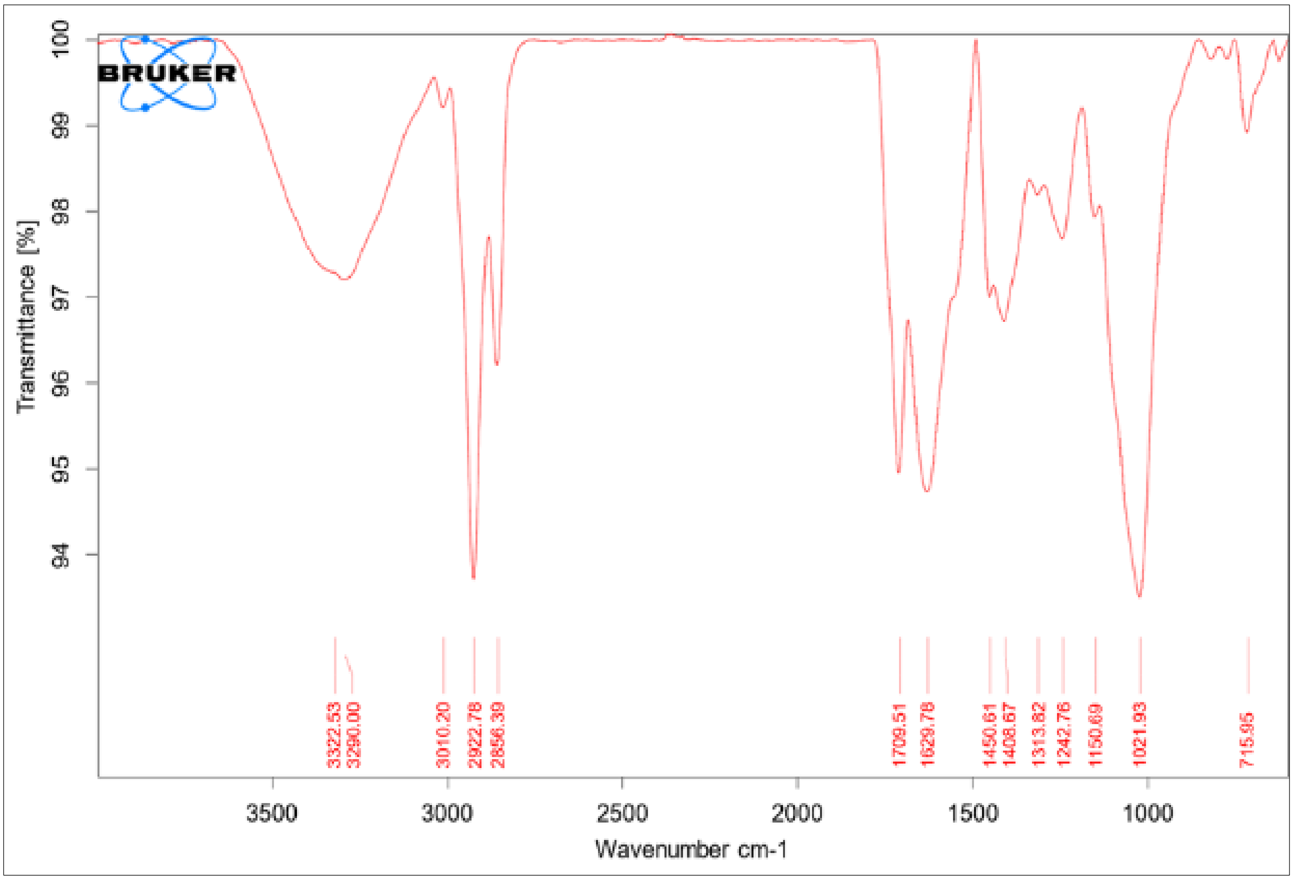

Fig 8: Infrared spectrum of sample CS4

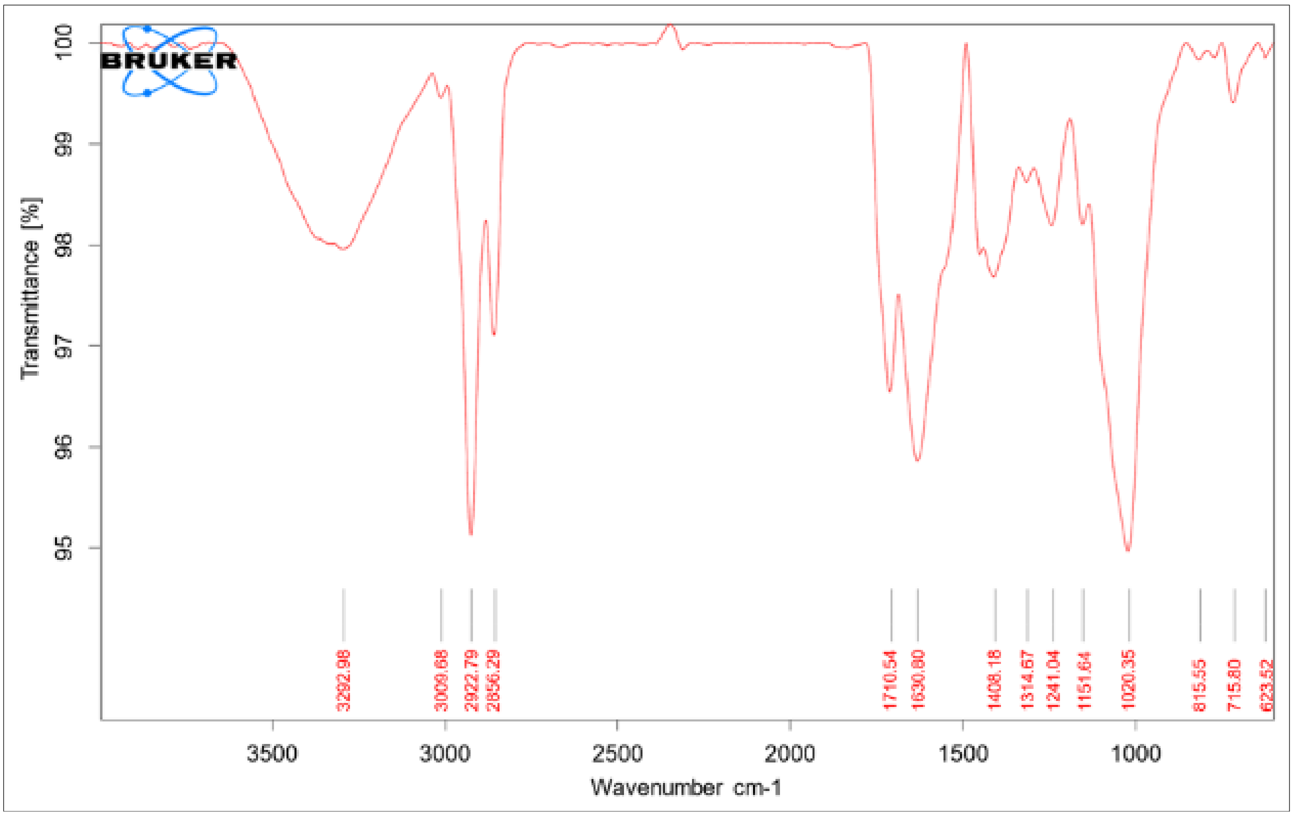

Fig 9: Infrared spectrum of sample CS5

Table 1 shows the results of Fourier Transform Infrared (FTIR) analysis. FTIR spectroscopy was utilized to evaluate the stability of chemical constituents and functional groups within the active components by analyzing stretching and bending vibrations within the infrared radiation spectrum. Shifts in the FTIR spectra resulted in different peaks, offering insight into the functional groups within the molecule. Coriander powder typically exhibit distinct characteristics in their FTIR spectrum.

Coriander powder contain various compounds such as fatty acids and essential oils, manifesting carbonyl stretching bonds typically between 1600-1740 cm^{-1}. This peak shows the presence of aldehyde, ketone and carboxylic acid. The carbonyl peak in CS1 is small and sharp but in the sample CS2 the peak is small but big and sharp than CS1. The CS3 sample has peak like CS2. The CS4 peak is big than CS3 and CS5 peak similar to CS3. The peak size difference in all samples is due to presence of adulterants. These bonds correspond to the vibrational characteristics of N-H amino acids. Aromatic compounds like phenolic compounds and aromatic hydrocarbons present in coriander powder often exhibit absorption bands around 3302.90 cm^{-1}, indicating O-H stretching vibrations. Although the H-O stretching peak in sample CS2 appears at the same position, it consistently appears at 3290 cm^{-1} in all samples, suggesting potential adulteration in samples CS1, CS3, CS4, and CS5.

Observations under the wave number 1018.5 cm^{-1} revealed that C-O stretches attributed to the presence of cellulose, ether and ester, which confirm the essential oil and flavonoids present in coriander powder samples. Additionally, the region of 1300-1400 cm^{-1} typically demonstrates the stretching vibration of C-O amides and C-C stretching from phenyl groups. Absorption bands ranging from 2922.69 -2855 cm^{-1}, specific to CH_3 and CH_2, represent stretching vibrations of aliphatic C-H bonds, potentially arising from compounds like fatty acids and aliphatic hydrocarbons present in the coriander samples.

Comparatively, minimum variation is observed between pure coriander powder and samples in the FTIR spectrum, with slight variations possibly due to factors such as seed variety, growing conditions, processing methods and presence of adulteration.

4. Conclusion

In the present work, the coriander powder collected from various grocery shop in Kanpur Nagar (Uttar Pradesh) and assess their quality and. composition through various chemical test and FTIR analysis. The chemical test we have performed firstly, phenol test showed consistent present in all samples, yet more pronounced in CS4 and CS5 indicating differences in composition or origin, similarly flavonoids were detected in all the samples but notably higher in CS3 and CS4 indicating the presence of adulterant in other samples. Tannins were present in all the samples except CS3, suggesting a unique composition or potential adulteration. The pH test revealed a deviation in CS3 indicating adulteration with alkaline substance. FTIR analysis further supported findings variation in functional groups and suggesting the presence of adulterants in some samples.

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