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# Unveiling the molecular profile of apple–beetroot blended powder through FTIR

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## ABSTRACT

*Fruit and vegetable are highly perishable commodities, they are prone to deteriorate rapidly after harvest due to lack of adequate postharvest facilities. Blending is the process of mixing two or more fruits pulp, juice or their concentrates which results in good combination of taste and nutritive value. Fruits and vegetables are abundant reserves of antioxidants, bioactive compounds, vitamins and minerals. In this research, the apple and beetroot pulp were used to obtain powders via cabinet drying at 60±2°C. The study employed Fourier transform infrared spectroscopy (FTIR), a sophisticated machine learning technique, to analyze powdered apples and apple-beetroot blends. The purpose of this study was to use the FTIR technique to assess the impact of processing on the powder's structure and to present precise information about the properties of powders. By determining the main functional groups, Fourier Transform Infrared Spectroscopy analysis of the powder further verified the presence of phenolics and betalains. Additionally, the presence of significant aromatic acid, ester and alcohol groups was revealed by Fourier transform infrared spectroscopy analysis. This product offer tremendous nutritional value and are ideally suited for wide range of consumers belonging to any age groups.*

***Keywords:*** *Apple, Beetroot, Powder,Phenols, Antioxidant activity, Ascorbic acid, Functional groups, FTIR.*

## Introduction

The nutrition's influence on human health has led to a practical shift in consumer preferences from highly processed ready-to-eat foods to natural or minimally processed food. Numerous scientists and researchers have demonstrated in recent years the importance of phytochemicals, particularly plant-based phytochemicals, in preventing and curing several feared human diseases [1,2]. Apple (Golden Delicious) is a fruit that is rich in proteins, fibres, vitamins and minerals, and has a wonderful flavour and taste [3]. The abundance of phytochemicals like epicatechin, quercetins, chlorogenic acid, phloretins, flavanols, procyanidin $B_2$ and procyanidins contributes to the antioxidative, chemopreventive, anti-neurodegenerative and anti-obesity qualities of apple phenolics [4]. The intake of apples and apple-based products has therefore expanded significantly as a result of their high phytochemical composition. Like other agricultural products with high moisture content, apples are subject to undesirable reactions that cause them to lose their quality [5,6].Beetroot is a highly esteemed root crop due to its diverse diet and its use as a salad, vegetable and herb worldwide [7]. Beetroots' phytochemical composition exhibits the existence of dietary fibres, proteins and ash, all of which are nutrient-rich as well as health-promoting. A vast range of vitamins and minerals found in beetroot highlights its health relevance [8]. Beetroot also contains a notable amount of health-promoting colouring components, for instance betacyanin, betalain, betaxanthin and carotenoids, which exemplify antiviral, antioxidant and antibacterial qualities. Compote and drying are the preservation techniques used to extend the shelf life and make fruits and vegetables available throughout the year [6].When it comes to yield, cost, energy and minimizing the amount of time that items are exposed to high temperatures, the drying process is preferable to its alternatives [9]. FTIR spectra analysis may be a valuable tool for differentiating between cultivars according to the amount of flavonoids, phenols, total carotenoids and other bioactive chemicals. In order to ensure that the apple powder could be dried in a cabinet, the current study was conducted to assess its applicability and then compare it to the developed apple-beetroot blended powder.

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## Material and Methods

Following the standard process provided by [10], the blended powder was made from blends of apple and beetroot pulp (Figure 1) in the department of Post Harvest Management, SKUAST-Jammu, India. Apple and beetroot pulp were blended in different proportions to prepare the powder, *viz.*, $T_1$ (100:00), $T_2$ (90:10), $T_3$ (80:20), $T_4$ (70:30), $T_5$ (60:40) and $T_6$ (50:50). At 60±2°C, the prepared mixes were dried for at least 8 hours in a cabinet dryer. Air velocity was set at 230 m/min and fan speed was set at 850 rpm.A grinder was used to grind the samples for at least 20 sec after they had been dried and allowed to cool to room temperature. The resulting powder was further sieved (60 mesh) and transferred into LDPE bags. After that, FTIR analysis was performed on the control sample, which was apple powder

($T_1$) alone and the best combination sample, which was $T_4$ (apple pulp: beetroot pulp: 70:30).

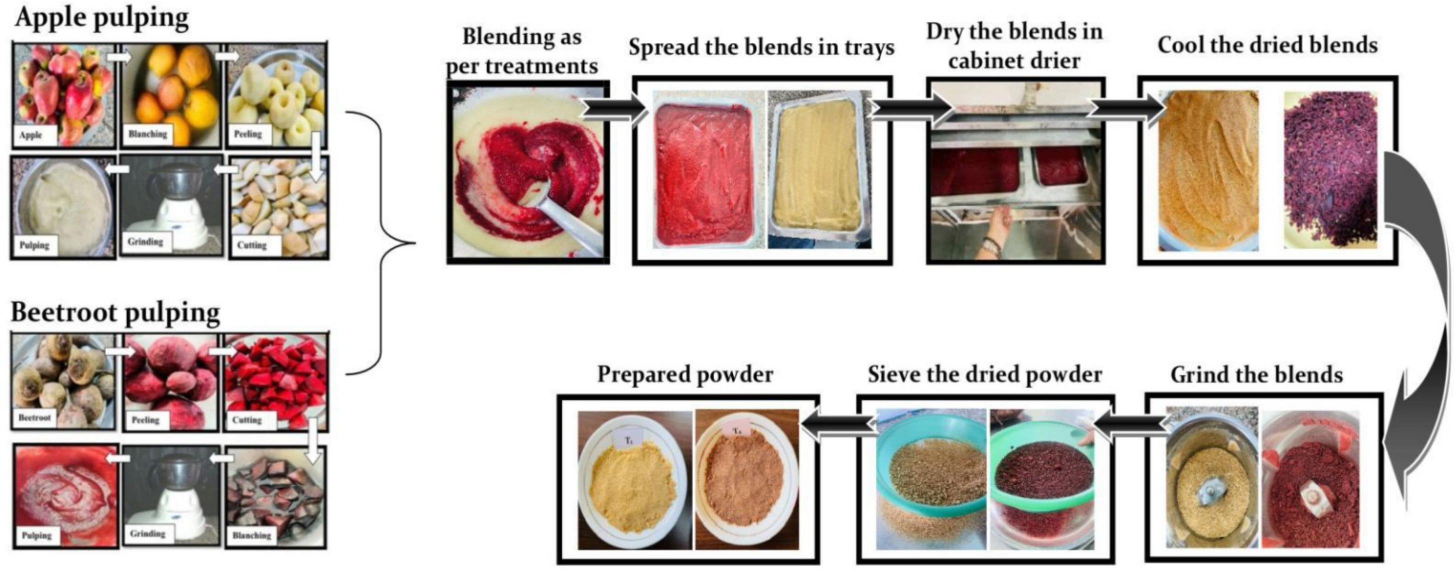


*Figure 1: Preparation of apple and apple-beetroot blended powders*

The method outlined by [11] was utilized to estimate ascorbic acid, with 2, 6-dichlorophenol indophenol dye. Total phenolic content of sample was estimated by Folin-Ciocalteau method [12]. Free radical scavenging activity was estimated using 1,1-diphenyl-2-picryl-hydrazyl [13]. The anthocyanin content was calculated at 530 nm [11]. Approximately 5 mg of sample and 5 mg of KBr were used for the qualitative analysis, which involved FTIR analysis of the apple-beetroot blended powder using a Shimadzu 8400S FTIR spectrometer fitted with a KBr beam splitter. The FTIR spectrophotometer was used with a maximum resolution of -0.85 $cm^{-1}$ and a spectrum range of 4000-400 $cm^{-1}$. Stuart's instructions for interpreting the spectra were used [14].

## Result and Discussion

### Proximate composition

The ascorbic acid in freshly prepared apple and beetroot powders were depicted (Table 1) as 11.29±0.05 mg/100g and 4.95±0.01 mg/100g, respectively which were closely related to the findings of [15], [9] and [16]. The anthocyanins content recorded in beetroot powder was 6.18±0.80%, which coincides with the findings of [10]. In freshly prepared apple and beetroot powders, the antioxidant activity was recorded as 5.39±0.12% and 12.63±0.23%, respectively which were in conformity with the findings of [17], [18] and [19]. The total phenols of apple powder were observed as 7.74±0.07 mg GAE/100g, whereas of beetroot powder were observed as 16.27±0.15 mg GAE/100g, respectively which were supported by the findings of [15], [20] and [21].

**Table 1: Proximate composition of apple powder and beetroot powder**

| Parameters | Apple powder | Beetroot powder |
|---|---|---|
| Ascorbic acid (mg/100g) | 11.29±0.05 | 4.95±0.01 |
| Anthocyanins (%) | - | 6.18±0.80 |
| Antioxidant activity (%) | 5.39±0.12 | 12.63±0.23 |
| Phenols (mg GAE/100g) | 7.74±0.07 | 16.27±0.15 |

### FTIR analysis

Apple and apple-beetroot (70:30) powders' micromolecular compositions were investigated using FTIR analysis. Figure 2a displays the FTIR spectra of apple powder. The frequency range at which the most prominent absorption peak was detected was 3305 $cm^{-1}$. O–H bond stretching and hydrogen bond vibrations are characterized by absorption bands between 3000 and 3500 $cm^{-1}$ [9].

In sugars, the C–H stretching connections fall within the frequency range of 2850 to 3000 $cm^{-1}$. The peak in the frequency range of 2931 $cm^{-1}$ was caused by C–H stretching. The valence resonance of $CH_2$ groups induces absorption bands for carbohydrates to form at a frequency of 2930 $cm^{-1}$, according to [22]. According to [23], triatomic molecules with double, triple, or even single bonds that remain out of the plane oscillate at lower energy levels and produce absorption bands at lower frequency ranges, whereas biatomic linear chained molecules held in a single plane vibrate at higher energy levels and so produce absorption peaks at higher frequency ranges. Peaks in the 1600-1695 $cm^{-1}$ and 1500-1585 $cm^{-1}$ frequency ranges correspond to amide C=O stretching, and α-$CH_2$ bending and C=O stretching of carboxylic acids and esters, respectively. The carbonyl stretching vibration in the amide bond is responsible for the absorption bond at 1634 $cm^{-1}$. 1415 $cm^{-1}$ is ascribed to either the O–H bonding vibration or the C–N stretching. The bioactive chemicals known as phenols, which determine the medicinal efficacy of plants, are known to absorb frequencies between 1270 and 1140 $cm^{-1}$, peaking at 1256 $cm^{-1}$. The peak that appears in the frequency range of 1060-1170 $cm^{-1}$ is caused by stretching oscillations in the C–O bonds of organic acids and sugars. The principal cause of the frequency range of 1100-1000 $cm^{-1}$, with a peaks at 1047 $cm^{-1}$ and 1026 $cm^{-1}$, is the vibration of the C–O–H group prevalent in primary and secondary alcohols. Apple powder's primary flavoring ingredients is alcohol, which is found in fruits [9]. CH bending and ring puckering are associated with the absorption peak between 780 and 846 $cm^{-1}$, whereas =CH and =$CH_2$ bending are highlighted by the peak observed in the spectral range of 880-1010 $cm^{-1}$. The presence of a C–C ring is indicated by the peaks in the FTIR spectra at 580 $cm^{-1}$ and 517 $cm^{-1}$.

The spectrum for apple-beetroot (70:30) blended powder (Figure 2b) at the optimized conditions showed a sharp peak at 3308 $cm^{-1}$ due to O–H stretching vibration, and the peak at 2932 $cm^{-1}$ that can be assigned to C–H stretching vibration of alkanes attributes to presence of carboxylic acids having O–H stretching showing the presence of citric acid [24]. The absorption band at 1789 $cm^{-1}$ is attributes to C=O stretching of aliphatic aldehyde, indicating the presence of aldehydes. The peaks between 1415 $cm^{-1}$ and 1645 $cm^{-1}$ indicate the presence of nitrogen-containing functional groups.

Presence of these nitrogen-containing functional groups confirmed the presence of betalains in dried powder [25]. A peak at 1047 $cm^{-1}$ and 1012 $cm^{-1}$ in the spectrum corresponds to the C–O–H vibration [26]. The peaks ranged between 1047 to 1398 $cm^{-1}$ denoting the presence of overtone bands of the O–H and C–H groups indicating the presence of different types of carbohydrates such as cellulose, hemicelluloses, lignin, pectin. On the other hand, exact peeks at 1047 $cm^{-1}$ and 1238 $cm^{-1}$ also denoting the presence of C–O stretching indicating the presence of phenols because C–O stretching in alcohols [27]. Absorption peak obtained in the frequency range of 550 and 520 $cm^{-1}$is the characteristic of C–C ring. The existence of functional groups is so obvious through comprising spectrums of the FTIR.

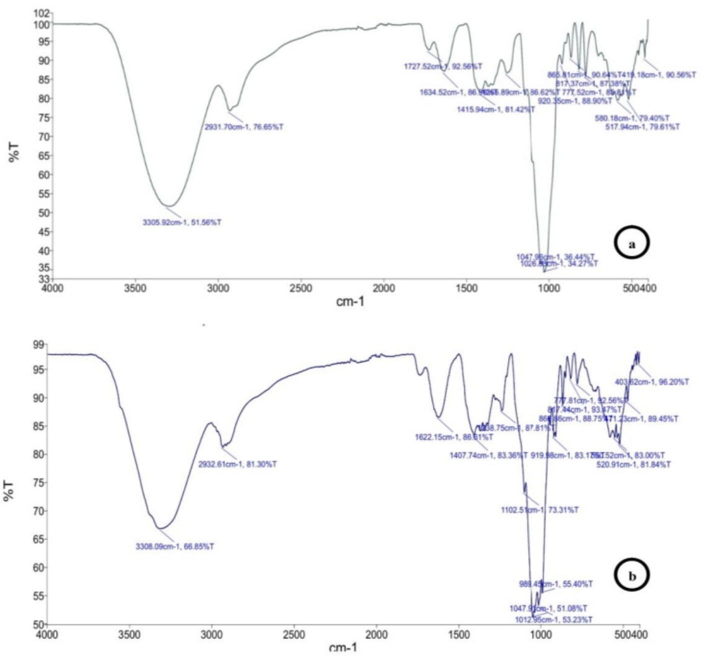


*Figure 2: FTIR analysis of a) apple powder and b) apple-beetroot (70:30) blended powder*

## Conclusion

This present study's methodology can verify the existence of key chemical components, including alcohols, phenols and aromatic acids, in apple and apple-beetroot powder. Apple powder and apple-beetroot (70:30) blended powder had the highest band intensities in FTIR spectroscopy, with wave numbers of 1026 $cm^{-1}$ and 1012 $cm^{-1}$, respectively. The method acquired enables the powders produced by cabinet drying to retain their authenticity and uniformity. Therefore, machine learning seems to be a useful technique for regulating the quality and authenticity of food products. The FTIR results affirmed that the produced powders were nutritionally rich due to the presence of naturally occurring functional groups. In the food industry, fruit, vegetable and their blended powder products thus hold a lot of potential for boosting nutritional value in forthcoming years.

**Future scope of the study:** Apple and Beetroot powder is a good source of bioactive constituents. Further studies on the incorporation of apple and beetroot powder into various food products like biscuits, snack bars and baked goods to enhance their nutritional value and potentially replace synthetic additives.

**Conflict of interest:** The authors declare no conflict of interest.

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