ORIENTAL JOURNAL OF CHEMISTRY
An International Open Access, Peer Reviewed Research Journal
www.orientjchem.org

ISSN: 0970-020 X
CODEN: OJCHEG
2025, Vol. 41, No.(1):
Pg. 25-29

Characterization of Mango with Physicochemical Analysis and Infrared Spectroscopy

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http://dx.doi.org/10.13005/ojc/410103

(Received: December 07, 2024; Accepted: January 20, 2025)

ABSTRACT

Mango *(Mangifera indica)* is a nutritious tropical fruit with a very high commercial demand. Mango can be eaten as fruit or else the mango pulp can be used as raw material for enormous food and agro-industries. As this fruit has achieved a worldwide commercial demand it is very important to grade and sort the quality mango for exportation. Aim of the present research work is to determine the different nutritional parameters to produce the knowledge about the good quality product. The study has been carried out with physical, chemical and spectral characterization of the mango fruit. Chemical data has been determined with Standard AOAC method. Spectral data has shown the molecules present in the mango pulp. To predict the spectral data, Near Infrared spectrometer with spectral range of 750-2500 nm and Fourier Transform Infrared Spectrometer with spectral range of 4000-400 cm^{-1} has been utilized. Physical and chemical parameters have explained the trend of attributes of the Indigenous mangoes.

Keywords: Fourier Transform Infrared Spectra, Mango, Mangifera indica, Near Infrared spectra, Physico-chemical properties, Tropical fruit.

INTRODUCTION

Mango, “the king of fruits” is one of the most popular tropical and nutritional fruits. Mango is having high water content, intense peel coloration and juice, fleshy, aromatic favorable taste. In terms of richness in nutritional values, mango is having good vitamin C, β-carotene and some other important minerals[1]. Mango is having the number of varieties. Depending upon its variations, the fruit size, shape, color, aroma, flavor and taste change accordingly[2-4]. Due to its delicious flavor, high nutritional values, excellent taste and low calories mango has achieved a good price and demand in world market[5]. India is the largest producer of mango with the 50% of production. In the year of 2010, the annual production of mango in India was 65000 tons[6]. Nowadays, the postharvest treatments are very important for the commercial purpose. The consumers are highly demand the quality of the exported fruit. So, it is very important to handle the fruits in a proper way after harvesting and to check its external as well as internal attributes before exporting. External qualities can be the size, shape of the fruit, the pulp and peel color, ripeness etc. and the internal attributes can be the different micro and macro nutrients, sweetness, aroma, water content etc.[7] Different properties like physical properties, physiological and nutritional attributes are playing role of the indicators of mango during the ripening stages. Now, to predict those external and internal attributes of mango mostly the destructive chemical approaches had taken places and some optical methods also have taken into the picture. Destructive methods destroy the intact fruits and the measurement and evaluations of checking the parameters were highly dependent on human labor, and also time consuming[2]. It also need some time technical trained stuff and liberal laboratory techniques and renders the fruit unusable[1]. Infrared spectroscopy is one of the most useful and cost effective quality analysis methods for qualitative and quantitative analysis. Near infrared spectroscopy has met the usefulness of non-destructive analysis of any sample[8,9]. It has developed the flexibility in time and labor to analyze any fruit sample. The spectrum of near infrared (NIR) region is having the overtone and combination bands of O-H, N-H, S-H, C-H fundamental bonds[10]. Fourier Transform infrared (FTIR) spectrometer also has done the same kind of analysis, but only played with the fundamental bands. A fundamental band does not contain all the information about any compound[11]. So near infrared spectroscopy has proved as a modified technology with rapid detection speed and nondestructive approach. This technology can easily compete with conventional chemical methods[12,13].

So, there was a strong purpose to introduce the non-destructive techniques like NIR spectroscopy and FTIR spectroscopy to peruse this research work on quality analysis of mango without any harmful chemicals. Many researchers have been proved the efficiency of IR spectroscopy for quality analysis of different food products, fruits, pharmaceutical products and many more[14-17]. The objective of the present study is to develop a basic idea about the qualitative and quantitative analysis of mango fruit, but a regression model can be developed with the chemmometric analysis to analyze the quality parameters of mango with non-destructive evaluation without any chemical use[8].

MATERIALS AND METHODS

Sample Collection

"Kishenbhog" ripe mature mango sample has been collected from the mango orchard firm from the Patna, Bihar and has been taken to the laboratory of Food technology department, advanced analytical research laboratory, Kolkata. The physical, chemical, rheological data has been determined from that concerned laboratory and then sample has been taken into CSIR-CSIO, Chandigarh and UGC DAE CSR, Research Centre, Kolkata for NIR and FTIR spectra collection respectively.

Sample Preparation

For physical attributes intact mango is the only need. So, after determination of physical parameters, the intact mango has been peeled and pulp from the mango has been collected for the chemical, rheological and spectral data collection.

Physical, Chemical And Rheological Analysis

For physical parameter determination vernier calipers are used and three axes that is major, minor and intermediate diameter has been calculated. Those three parameters are having important role to calculate the most of the physical attributes like size, sphericity and surface area of the intact mango fruit. Other than that, intact fruit weights, pulp weight, peel weight and kernel (seed) weight has been recorded.

Chemical parameters have been determined with the standard AOAC methods[18]. The methods are oven drying method for moisture analysis, muffle furnace method for ash content determination, Soxhlet method for fat determination, Kjeldahl method for protein determination, and Acid-alkali digestion method for fiber determination.[19-20] Total soluble solid content and pH value of the mango pulp has been evaluated with the automated hand refractometer and pH meter respectively. For carbohydrate content analysis difference method has been used. The formula is followed:

Carbohydrate (%) = 100 – [Protein (%) + Fiber (%) + Fat (%) + Moisture (%) + Ash (%)] (1)

Energy values (in Kcal) has been calculated with the formula given by Osborne and Voogt

Energy (Kcal/100g) = [9 x fat (%) + 4 x carbohydrate (%) + 4 x protein (%)] (2)

In rheological attribute viscosity of the pulp sample has been determined with viscometer.

Spectral Data Collection

The spectral data has been recorded into two parts. One is NIR spectra and another one is FTIR spectra. NIR spectra has been collected with the NIR DOSS2500 spectrometer between the spectral range of 700-2500 nm and FTIR spectra has been collected with Perkin Elmer FTIR spectrometer with KBr pallets between the spectral range of 4000-700 cm^{-1}.

RESULT AND DISCUSSION

The physical and chemical properties can be written together as physicochemical properties. Table 1 has clearly shown the physicochemical properties of the mango pulp and size, sphericity and surface has been calculated with the mathematical formulations.

Those formulas can be present as,

Size (Dg) = $(a \times b \times c)^{1/3}$ (3)

Size can be denoted as the Dg and in this formula a, b and c are the major, minor and intermediate axis respectively. The values of “a” is expressed as 10.77 cm, “b” is expressed as 7.97cm and “c” is expressed as 9.06 cm. The formula for the surface are can be presented as,

Surface area (Sa) = π $(Dg)^2$ (4)

Finally, the sphericity (Φ) can be expressed as,

Sphericity (Φ) = Dg/a x 100% (5)

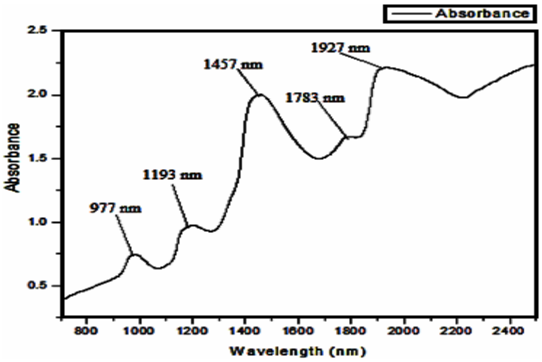
From the Table I., it can be clearly depicted that in an intact fruit the percentage of the pulp is more, as compared with the peel and kernel for this sample. So, this mango is a fleshy mango with juicy flavor, as it has high water content (Table I). Mango is a good source of energy and also it has been observed that this mango is having good protein content. pH is one of the most important quality parameter to predict the taste of the fruit. As, it is having the pH value less than 7 it observed as an acidic fruit.

Table 1: Physical and Bio-chemical attributes of the mango pulp

Physical and Rheological Parameter	
Intact fruit weight (Grams)	507.000
Pulp weight (Grams)	385.000
Peel weight (Grams)	68.000
Kernel weight (Grams)	54.000
Size (Cm)	9.1960
Surface area (Cm^2)	265.625
Sphericity	0.8538
Viscosity (Pa.S)	30.651
Bio-chemical Parameter (gram/100g)	
Moisture content	86.851
Ash Content	0.405
Crude fat content	0.455
Crude protein content	5.15
Crude fiber content	0.695
Energy (Kcal)	50.475
Carbohydrate	6.445
Total Soluble Solid	15.000
pH	4.215

* All the weight values in physical parameters presents in gram, size presents in cm, surface area presents in cm2 rheological parameter i.e. viscosity in mPa.S and all the bio-chemical parameters presents in g/100g. Energy value presents in Kcal

Near infrared and Fourier Transform infrared spectroscopy both are the non-destructive and rapid techniques. But if the comparison occurs NIR is the best approach with some limitations. Both the radiations can vibrate the organic molecules and with the vibrational transitions Fig. 1 and 2 has been recorded. With these two methods there no sample preparation has been done in the present research. NIR radiation can be much more penetrable into the sample as compare to FTIR radiation. As, FTIR can only penetrate at very shallow depth, it has shown the (Fig. 2) the fundamental organic bands. There are total four major peaks has been shown in Fig. 2. At 3394 cm^{-1}, a broad band has shown, which indicates presence of huge amount of water in the mango pulp. Generally at that peak many organic molecules can be vibrated that is O-H stretching, N-H stretching, B-O-H stretching and Si-OH stretching. At 2916 cm^{-1} aldehyde C-H stretching can be assigned. At 2137 cm^{-1} Azide N=N stretching, C=C stretching can be vibrated and finally primary amide NH_2 bending band and C=C stretching band can be occurred at 1637 cm^{-1}. As NIR spectra can radiate into the higher depth into the sample as compare to FTIR radiations, it has shown (Fig. 2) the harmonic and combination band of fundamental bands. But in NIR region the bands are not that sharp due to the higher frequencies. In Fig. 1, second harmonic of O-H bond due to the presence of water in the sample has occurred at 977 nm. Second harmonic of C-H stretching band has occurred at 1193 nm due to the present of lipid in the mango pulp. First over tone of N-H stretching has been assigned at 1457 nm due to the presence of protein. First harmonic of C-H and combination of O-H band has been assigned at 178 nm and 1927 nm respectively due to the presence of cellulose and starch in mango pulp[19].



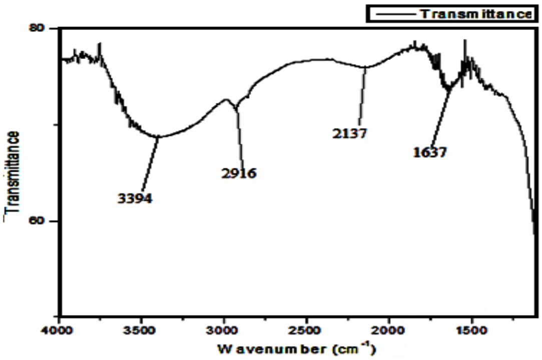


Fig. 2. Fourier Transform infrared fingerprint of mango pulp

CONCLUSION

This research has concluded with some basic data and has given a lot of scope for advance analysis. Destructive way to analyze all the nutritional parameter present in mango pulp has been determined and concluded with the higher concentration of water, protein and carbohydrate in the mango pulp. Also mango is a good source of energy (in Kcal). A non-destructive approach has also been taken to analyze the organic compounds present in the mango. Physical parameters has depicted the amount of pulp is more than the sum of amount of peel and seed of mango. Radiation of different regions has been used and compared both the results to judge the utility. Although FTIR spectroscopy can detect the fundamental bands, but to know the overtones and combinations band NIR spectroscopy is having a key role. In future, with the large scale of data a regression model can be made to predict those nutritional parameters with chemmometric analysis.

ACKNOWLEDGEMENT

We are thankful to Dr. Sutapa Bhowmick, Laboratory Head, Advanced Analytical Testing Laboratory, Kolkata, West Bengal, Dr. Sunita Mishra, Principle Scientist, CSIR-CSIO, Chandigarh and Dr. Gautam Pramanik, Scientist D, UGC DAE CSR, Kolkata research Centre, Kolkata for providing their facilities to carry out the research work successfully.

Conflict of interest

The author declare that we have no conflict of interest.

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