CHAPTER IV
DETERMINATION OF THE ADULTERATION IN HONEY

4.1 INTRODUCTION

Honey is the natural complex food product produced by bees from nectar of plants and also from honeydew. It is a unique sweetening agent that can be used by humans without processing. Bee honey has significant nutritional and medicinal benefits. It is a rich source of readily available sugars, organic acids, various amino acids and an additional source of many biologically active compounds.

Normally, honey contains 12.4 – 20.3% moisture and 60.7 – 77.8% sugars, of which about 0 – 2% may be sucrose, 25.2 – 35.3% glucose, and 33.3 – 43% fructose and less than 0.25% of ash.

Honey has always been an easy target of adulteration for economic gains. Being a natural product, the composition of honey is highly variable. Honey adulteration has evolved from the basic addition of cane sugar and water to specially produced syrups for which the chemical composition approximately reproduces that of natural honey. Therefore, there is a need, for the development of more sophisticated methods to detect honey adulteration.
A number of methods exist to check the adulteration, one of which commonly used is the pollen analysis. It can demonstrate the addition of syrup by the microscopic detection of cane sugar annuli or parenchyma, or starch grains [8]. This technique provides very good results [30]. But the ultrafiltration of the honey, limits the applicability of this method for the determination of the purity/adulteration [31].

The other method available in the literature is based on the stable carbon isotope ratio analysis (SCIRA). This method is based on the difference in isotopic carbon composition that depends on the origin of the plant. The creation of database on the isotopic contents of the honeys (mostly from C3 plants) has revealed that these contents are relatively uniform [9]. It was thus, possible to detect the addition of a corn or cane sugar syrup from C4 plants. But, this method is useful only if the adulteration is about 20%. Few studies concerning adulteration detection in honeys by chromatographic methods have also been reported [10-11]. However, these methods have the drawbacks of slow testing and expensive experimental set up.

The proposed electronic technique to be discussed in the following article is based on the variation of the dielectric properties of the food materials. Various factors which can influence the dielectric properties of foods are moisture, ash, electromagnetic waves and the physical state of food [32].
It is well known that the value of the capacitance of the capacitor depends on its geometry and the physical properties (dielectric constant) of the material placed between the plates. Thus, the capacitive methods can be used for the determination of the composition of binary mixtures of nonconducting fluids where they differ in their dielectric constants. The present technique involves the measurement of the capacitance of the mixture (adulterated honey) with the variation of its dielectric constant, depending on the percentage of adulteration.

Later on the variable capacitor referred to above is connected in the circuit of a relaxation oscillator. The change in capacitance modulates the output frequency of the oscillator. The frequency of the output signal is measured using the digital counter. Thus, the output frequency of the circuit is a measure of the adulteration of the honey.

4.2 THE CAPACITANCE BASED TECHNIQUE

A parallel-plate capacitor with plate area ‘a’ and plate separation ‘d’, filled with a dielectric material, is shown in Fig. 4.1 and its capacitance, C is given by [33]:

\[ C = \varepsilon_0 \varepsilon_r \frac{a}{d} \]  

(4.1)
Figure 4.1 Dielectric based capacitive transducer.

Figure 4.2 Capacitance to frequency conversion using Relaxation oscillator.
where, \( \varepsilon_r \) is the dielectric constant of the material (Honey in this case) between the plates and \( \varepsilon_0 \) is the permittivity of the free space.

If such a capacitor is connected in the circuit of a relaxation oscillator shown in Fig. 4.2, it is converted into a period-modulated output signal [34-35]. This oscillator relies on an RC circuit, formed by the Resistor \( R_C \) and Capacitor \( C \) and a comparator as a Schmitt trigger. The period \( T \), of the output signal is proportional to the Capacitance, and may be expressed as:

\[
T = R_C C \ln \left[ \frac{V_{DD} - V_{TL}}{V_{DD} - V_{TH}} \right] \quad (4.2)
\]

The threshold voltages, \( V_{TL} \) and \( V_{TH} \) of the Schmitt-trigger comparator are given by:

\[
V_{TL} = V_{DD} \frac{R_2 \parallel R_3}{R_1 + R_2 \parallel R_3} \quad (4.3)
\]

\[
V_{TH} = V_{DD} \frac{R_2}{R_2 + R_1 \parallel R_3} \quad (4.4)
\]

Where, \( V_{DD} \) is the fixed dc voltage.

If we select \( R_1, R_2 \) and \( R_3 \) of equal value, then \( V_{TL} \) and \( V_{TH} \) take the following forms:

\[
V_{TL} = V_{DD} / 3 \quad \text{and} \quad (4.5)
\]

\[
V_{TH} = 2V_{DD} / 3 \quad (4.6)
\]
A substitution of $V_{nl}$ and $V_{tm}$ from Eq. (4.5) and (4.6) in Eq. (4.2) results in:

$$T = R_c C \ln 4 \quad \text{or} \quad f = \frac{1}{R_c C \ln 4} \tag{4.8}$$

where, $f$ is the frequency of the output signal.

If $R_c$ is kept constant, it is evident from Eq. (4.8) that the frequency $f$, of the modulated output signal is inversely dependent on the capacitance, $C$ used in the circuit.

### 4.3 EXPERIMENTAL METHOD

The capacitor for experimentation was formed by a pair of individual platinum electrode on glass wands with square shape having dimensions of 5mm x 5mm and a separation of 5mm. The charging resistor $R_c = 100k\Omega$ was used in the circuit and the IC 356 was used as a Schmitt trigger.

Pure honey was adulterated with different quantities of syrup to obtain a number of samples. These samples were mixed thoroughly and kept at the room temperature. For each test, approximately 2 g of the honey sample was placed as a dielectric material between the plates of the capacitor.

The measurement of the capacitances so formed were performed with the help of HP 4284 A, an LCR apparatus from Hewlett Packard, USA. The
variation of frequency, \( f \) of the output signal shown in Fig. 4.4 was recorded by a digital frequency counter.

### 4.4 MEASUREMENT RESULTS

The measurement results of the capacitances of the adulterated honey samples are presented in Fig. 4.3. It can readily be observed from the graph that the capacitance of the sample increases with the increase in the adulteration of the honey.

The charging resistor,  \( R_c \) is selected as 100 kΩ for the circuit of Fig. 4.2.

The variation of the measured capacitance \( C \) is shown in Fig. 4.3. It varies between 20 pF and 500 pF for adulteration from 0 to 100 percent.

As per the Eq. (4.8) and the experimental setup of Fig. 4.2, the measurement of the relaxation oscillator frequency with percentage adulteration is also shown in Fig. 4.4. It can be observed from the variation that the frequency of the output signal decreases from 308 kHz to 12.34 kHz for increase in adulteration from 0 to 100 percent.
Figure 4.3 Variation of Capacitance with adulteration.

Figure 4.4 Variation of frequency with adulteration.