Electrical Methods for Detection of Adulterants in Milk

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Abstract: Addition of substances in a product that results in unhealthy and harmful effects when consumed is called adulteration. This is done to increase the quantity of the product to gain profit. Adulteration is very common in almost all the countries and adulteration of milk is a very serious problem. India is the largest producer of milk but due to its growing population and therefore more requirements, milk adulteration is very common here also. Adulteration is not always to make greater profits but sometimes it is due to the lack of knowledge and skill in storing and transporting the milk. There are so many methods for milk analysis and very popular and common ones are chemical methods. Since, in developed countries advanced methods are used to adulterate milk and sophisticated methods are used to detect it therefore researchers proceed for electrical methods which are accurate, data can be stored and automated and the instrument can be made handy. In this paper different electrical techniques for detection of adulterants in milk are discussed.

Keywords: Adulteration, Milk, Electrical Methods, population, sophisticated

I. INTRODUCTION

The common adulterants in milk are starch, urea, vegetable oil, sugars, whiteners etc. These adulterants make the milk tastier. Addition of these substances results in increase in quantity but quality of milk becomes low. Consumption of such type of milk results in various health problems such as heart diseases, kidney related problems and intestinal infections. A national survey shows that 70% of our nation's milk is adulterated with detergents, neutralizers but impure water is the major contaminant. The conventional methods such as chromatography, spectroscopy, and osmometry are tedious, time consuming and expensive, capillary electrophoresis, thermometric sensors, mass spectrometry, etc.

II. ADULTERANTS AND THEIR EFFECTS

Addition of substances in milk not only decreases its nutritional value but also pose risk to health. Some of the common adulterants in milk are discussed here.

A. Antibiotics

Various antibiotics are used for the treatment of diseases in cattle. Mastitis is a very commonly occurring problem in dairy herds. These antibiotics are found in large quantity in milk. Antibiotics are also added to increase shelf life of milk. These are dangerous to human health and therefore its detection in milk is very necessary. There are various detection techniques available in literature but the commonly use electrical methods are milk detection using electrical conductivity; biosensor array and E-nose are the detection methods for antibiotics in milk.

B. Water

Sometimes use of contaminated water causes health problems and lower down its nutritional value. Addition of water changes specific gravity of milk.

C. Chlorine

Chlorine is added to compensate the density of milk which changes after addition of water. Potentiometric method and Coductometric Sequential Injection Analysis are used to detect the presence of chlorine in milk.

D. Non milk proteins

Non milk proteins e.g. soy milk, pea etc. and whey powder are sometimes added to milk. Milk fat is the costliest among all the milk constituents and is being removed from the milk to sell it separately. Fatty substances and vegetable oils are mixed in milk to compensate the quantity of fat. Conductivity method, electrophoresis and e-noses are used to detect presence of these adulterants in mil

E. Colour

Addition of various substances in milk results in change in colour of milk and therefore certain colouring materials are mixed to retain its natural colour. Capillary electrophoresis method is used to detect colour as adulterants.

F. Preservatives

Formalin is a common preservative to increase shelf life of milk. Preservatives can be detected using electrical methods are E-tongue, conductivity, impedimetric, capacitance method.

G. Neutralizers

Conductivity and pH measurement are often used to analyze the neutralizers in milk and other dairy products. Milk contains bacteria converts lactose into lactic acid .This results in change in electrical parameters. Fourie et.al reported impedance probe to measure bacterial content in milk.

III. ELECTRICAL METHODS FOR MILK ANALYSIS

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The electrical properties of milk under controlled circumstances depend upon different parameters such as measuring current, voltage, frequency, impulse, type of electric current, experimental conditions and different chemical components in raw material and their degree of dissociation. Milk has high water and mineral content and is

Characterized by good ionic conductivity. The relationship between milk constituents and their electrical properties has been investigated and applied for quality evaluation. Zhuang et.al (1997) found statistically significant coorelation between the protein content of a commercial whey powder determined using electrical conductance method. Mabrook and petty (2003) used the method of electrical admittance spectroscopy to study the water and fat content of milk.

A. Potentiometric Methods

In potentiometric biosensors the ion-selective electrodes are used in order to transduce the biological reaction into an electrical signal. It is basically consists of an immobilised enzyme membrane surrounding the probe from a pH meter, where the catalysed reaction generates or absorbs hydrogen ions. The reaction occurring next to thin sensing glass membrane causes a change in pH which may be read directly from pH meter. Typical use of such electrode is that the electrical potential is determined at very high impedance allowing effectively zero current flow and causing no interference with the reaction. Potetiometric biosensors are used to detect presence of urea in milk. Amperometric biosensors are use to detect lactose level in milk.

The potetiometric electronic tongue is used to detect the quality of milk. Data from electronic tongue is processed by Principal Component Analysis (PCA) or ANN.

B. Conductance Measurement

Conductivity (or electrolytic conductivity) is defined as the ability of substance to conduct electric current. It is the reciprocal of resistance. Conductivity of cow milk lies between 4 to 6 mS/cm and that of buffalo milk lies between 3 to 5 mS/cm, both at 18^0 C. To eliminate the effect of electrode polarization, the conductance of milk was measured at high frequency.

The conductivity of milk depend on two major parameters namely impedance, the main component of which is resistance and admittance, the main component of which is conductance. The electrical conductivity is also been studied to detect freshness and adulteration of milk. The salt content of pure milk is constant. The addition of adulterant change the salt concentration which results in change in conductance with frequency ranges from 20Hz to 1MHz. conductance of milk decreases with the increase in temperature. Sadat et al2006 detects adulteration of detergents and synthetic milk using alternating current conductance from 20 Hz to 1Mz. Natural milk shows higher conductance at 100 KHz. The addition of synthetic milk decreases the conductance with respect to the concentration added to natural milk.

C. E-Nose

An electronic nose is a device that identifies the specific component of an odour and analyzes its chemical form to identify it. An electronic nose consist of a mechanism for chemical detection, such as an array of electronic sensors and a mechanism of pattern recognition e.g. PCA and ANN E-noses can monitor the ageing of milk .There are reports (Capone et.al) in which e-nose is used to measure the development of rancidity in pasteurized milk. E-noses are also used to detect antibiotics and non milk proteins.

D. E-Tongue

Same as with electronic noses, different sensing principles can be used with electronic tongues or taste sensors. A wide variety of chemical sensors can be employed into their design, electrochemical (potentiometric, voltammetric, impedimetric), optical and biosensors. Ion- Selective electrodes and Ion-selective field effect transistors are nowadays used in forming e-tongues.

Potentiometric electrodes are most widely used sensors in electronic tongue system. The sensing mechanism of most of the potentiometric sensor is based o the membrane made of inorganic or organic materials.

E. Ultrasonic Detectors

Ultrasound is defined as the sound waves having frequency more than human hearing range i.e. beyond 20KHz. Ultrasound wave is one of the emerging technologies that were developed to minimize processing, maximize quality and ensure safety of the food.

Chemical additives are to increase its shelf life. The common additives are sodium carbonate, bicarbonate and formalin. These are also used to prevent curdling of milk. Mohanan et al. reported the study of thermo acoustic analysis to detect chemicals by measuring density and ultrasonic velocity.

F. Piezoelectric Sensor

Piezoelectric sensor is a device that uses the piezoelectric effect to measure changes in pressure, strain and force etc.

An enzyme based sensor for detection of urea in milk was constructed using a piezo electric sensor, which measures the pressure of the gas evolved from the sample. The sensor showed linear behaviour for varying concentration of urea in the samples. The time response of sensor was evaluated and the results showed that this technique can be used to detect urea content in milk. (Renny et al 2005)

IV. CONCLUSION

Detection of adulterant in milk is very complicated process. Since advanced methods are used to adulterate milk therefore it is necessary to use sophisticated method for detection and researches are going on to develop new technologies to improve the quality and prevent the mankind from this fraud. The electrical methods discussed here are nowadays very commonly used and can be made portable which can be used easily and everywhere.

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