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A Review on Detection Techniques to Quantify Nutritional Constituents of Milk

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ABSTRACT: Milk is an essential part of human diet, also milk in its raw form consists high numbers of its constituents just because it is a undeniably better source of natural and pure source of fats, lactose, proteins, minerals and vitamins. The major source of milk is from cows (world wide including India) and buffaloes (India). Most of the time many people prefer to consume cow's milk just for its health benefits. On the other hand, many people are inclined to drink buffalo's milk. The main question arises here is 'how to find out which is which?' and 'how to quantify the nutrients?' Numerous studies and methods have been explored to find out precise information of the milk including its source. There are methods available to sort these milks out but these methods are expensive, laborious and time consuming. In this study, we will take a look on the areas which are not explored yet, and are potentially showing more room for further studies in this particular field. Then we will discuss a portable instrument, which has not been developed yet, but can be useful and helpful along with an idea of using machine learning to predict whether that is a cow's milk or buffalo's milk, from the images recognition only

KEYWORDS: milk, cow, buffalo, portable, instrument.

I. INTRODUCTION

Milk is an essential part of human diet, also it has lot of minerals and vitamins. Most importantly, protein is the main constituent which makes it more valuable but there are lot of factors that affects on the quality of milk, also milk in its raw form consists high numbers of it's constituents just because it is a undeniably better source of natural and pure source of fats, lactose, proteins, minerals and vitamins [1].

Numerous studies and methods have been explored to find out precise information of the milk but most of the time many people prefer to consume cow's milk just for its health benefits. On the other hand, many people are inclined to drink buffalo's milk and it's worldwide production reached at 659 and 111 million tons respectively in 2016 [2]. The main question arises here is 'How to find out which is which?' there are methods available to sort these milks out but these methods are expensive, laborious and time consuming. Nonetheless, even if we choose best milk out there still consumers are oblivious of one main and foremost factor is SCC (Somatic Cell Count) higher the SCC poor the quality of milk and vice versa.

Also, there are loads of procedures and devices available to measure milk's quality such as, high performance liquid chromatography method for lactose content [3], Kjeldahl method for protein content [4], Rose Gottlieb method for fat content [5] and direct forced air oven drying method for total solids, it is essential to measure these charges to make dairy product's quality transparent. Moreover, it is very important to identify the adulteration of the milk, water is the economic adulterant of the milk. It is usually mixed to increase the amount of milk in order to raise the profit, which in result lowers the quality of the milk and can be dangerous for human being. Most of the time, cow milk is mixed with goat or buffalo milk to make profit. Hydrogen peroxide is added into the milk to increase it life which has bad effects on human health. Similarly, urea is used to maintain the density and fat content in the milk.

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II. LITERATURE REVIEW

i. MAIN NUTRITIONAL CONSTITUENTS IN MILK

The most part of milk is aqueous solution of lactose, minerals, vitamins, and other small molecules. Besides the solution, proteins at the molecular level (whey proteins) or as large colloidal aggregates (casein proteins, 50–600 nm) and lipids as globules (0.1–20 mm) in an emulsified state were dispersed in milk [5]. Many factors, such as species, individual, stage of lactation, feed and health, have influences on the compositions of milk [6]. Milk fat is mostly contained in fat globule which is the core of triglycerides surrounded by a membrane. In the milk of most species, 97–98% of the total lipids are triacylglycerols (TAGs). Other lipids like diacylglycerol, cholesterol, phospholipids, and free fatty acids (FFAs) can also be found. Since TAGs are the main parts of milk fat, the properties of milk fat such as density and melting profile are mainly influenced by TAGs. There are more than 400 different fatty acids (FAs) in milk fat, which is much more than in other fats. From a practical viewpoint, milk fat gives distinctive properties in nutritional, textual and organoleptic aspects of dairy products such as butter, cream and cheese. Milk contains hundreds of types of proteins, which could be divided into three kinds, that is, casein proteins, whey proteins and minor proteins. Most of the casein proteins existed in a colloidal particle is known as casein micelle. There are two kinds of whey proteins, that is, b-lactoglobulin and a-lactalbumin, which can result in allergy even at a very low concentration[7]. Each protein has its specific biological functions [8]. Both of them are classified as high-quality proteins since they meet the human requirements on amino acid with high digestibility and bioavailability.

Lactose is the main carbohydrate in the milk of most species and is regarded as a ready source of energy for the neonate. In the formation of neural system and growth of skin (texture), bone skeleton and cartilage in infants, lactose also has an important impact. However, lactose intolerance can result in different degrees of abdominal discomfort, bloating, diarrhea and flatulence due to insufficient amounts or activity of lactase in the human intestine.

In addition to the main constituents described above, several hundreds of minor constituents, for example, minerals and vitamins, are also significant for the nutritional, sensory and technological properties of milk. The milk minerals, including citrates, phosphates, chloride, potassium, sodium, magnesium, and calcium, exist as ions in solution or as colloidal species complexed with caseins. These minerals are essential for human nutrition. For sustaining life and promising good health, vitamins are necessary microelements [9]. There are two groups of vitamins in milk according to their solubility, that is, water-soluble vitamins and fat-soluble vitamins. Both water-soluble (B complex and vitamin C) vitamins and fat-soluble (vitamin A, D, E) vitamins are contained in milk.

ii. RAPID DETECTION TECHNIQUES

a. Chromatography

Chromatography, such as high performance liquid chromatography (HPLC) and gas chromatography (GC), is very useful in complex food analyze since they combine the separation and detection steps together. In principle, HPLC can be used to separate any dissolved analytes by using different techniques. Reversed-phase HPLC (RP-HPLC) is the most commonly used HPLC techniques. Many different detectors such as refractive index detector (RID), evaporative light scattering detector (ELSD), pulsed amperometric detection (PAD), mass spectrometry (MS), photometric and fluorescence are usually used in HPLC. GC is generally applied for compositional analyses of thermally stable compounds that are volatile or become volatile using derivatization. Flameionization detector (FID) and MS are the most commonly used detectors in GC analysis [10].

b. Spectroscopy

Raman, MIR (2500–25000 nm), NIR (780–2500 nm), and Vis-NIR (400–2500 nm) spectroscopy are widely applied in constituent analyses of milk. Raman spectroscopy is based on vibrational, rotational and other low-frequency modes. Without the interference of water, Raman spectral analysis is suitable for a wide range of liquid products (Jha et al. 2016). MIR, NIR, and Vis-NIR spectroscopy express typical vibrations of covalent bonds in molecules. Therefore, their spectra contain quantitative information about all the compositions that absorb infrared radiation [11]. These infrared methods are

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mainly based on the absorption, provided the scatter is possibly avoided or suppressed. Besides Raman, MIR, NIR, and Vis-NIR, other spectroscopy techniques such as ultraviolet (UV) spectroscopy [12], fluorescence spectroscopy [13] and atomic spectroscopy [14] have also been used in the milk quality analysis.

c. Dielectric Properties

The usually interested dielectric properties include dielectric constant and dielectric loss factor, which are the real and imaginary parts of the relative complex permittivity, respectively [15]. Dielectric properties are inherent properties of materials and they explain the interactions of materials with electric field. The dielectric constant reflects the ability of a sample in storing electric energy, and the loss factor shows the ability of the material in dissipating electrical energy into heat [16]. Many studies have shown that the dielectric properties of materials not only depend on the temperature and frequency of electric field but also rely on their physical and chemical characteristics like density and compositions [17]. Therefore, the dielectric properties have usually been used to determine the compositions of food, including milk.

Sensors

In recent years, sensor technology has received considerable attention and developed rapidly. Many efforts have been devoted to develop in-line/on-line sensors based on different principles for detecting the compositions of milk or dairy products, such as microwave sensor [18], optical sensor [19], resonant cavity sensor [20], biosensor [21], and photoelectric sensor [19]. When compared with other traditional methods, the biosensors developed by using various biological materials have greater potential in practical applications with some prominent advantages such as fast determination, simple procedure, low cost, high sensitivity, and excellent selectivity [22].

d. Sensor Fusion Method

Till the date, many researches and studies have been done regarding the different procedures of finding out milk's nutritional values. But there is still lot of space available to explore more accurate method to find out these same parameters. One of which is Sensor Fusion Method (SFM) this defines, in other words, that more the data greater the accuracy. In this method multiple sensors can be used to measure single parameter which in turn increases measurement accuracy. Protein and fats, for instance, are the main parameters of measurement. If two of more sensors are connected to measure only protein and two or more sensors to calculate fats in the milk then after collecting and processing the measured data of these number of sensors. After then, it's mean will be of high accuracy.

III DISCUSSION

Up to now, the combinations of chromatography with other detection techniques have become an important technology in analyzing food composition, especially for trace contents, and have been successfully applied for the compositional analysis of fat, protein, lactose, minerals, and vitamins in milk owing to its high sensitivity, flexibility and specificity. However, these techniques usually include extraction and separation steps, causing professional technicians needed, time and chemicals consumed and pollution on environment. Therefore, chromatography technology cannot be used in situ or in the field, and cannot meet the in-line/online purposes. Moreover, due to the expensive chromatography instruments and the high cost of acquisition and operation of systems, the technologies are just used in large analytical laboratories and applied as a reference to other methods.

Being a well-established laboratory technique, MIR spectroscopy has been widely regarded as a reference analysis method for the main constituents of milk due to its high sensitivity and selectivity [23]. At present, Fourier-transform mid-infrared (FT-MIR) spectrometry is the most widely used method worldwide for compositional analysis and quality checks during routine liquid milk testing.

The changed dielectric properties with compositions in milk have also been used to detect fat and protein contents of milk. Dielectric spectroscopy has the advantages of high speed, little or no sample preparation, nondestructive measurement, wide wavelength range and multiple analyze from a scan. It has great potential for in-line/on-line quality analysis. Therefore, applying dielectric properties for determining the main nutrients of milk has great potential. However, since many factors including physical and chemical properties, such as structure, ions, water, fat, and protein, have a comprehensive influence on dielectric properties, applying dielectric properties to predict the main nutrients of milk precisely is a big challenge.

Compared with other rapid detection methods, chromatography has been widely utilized in the analysis of components such as fat, protein, lactose, mineral, and vitamins in milk due to its outstanding advantages of sensitivity, flexibility and specificity.

Due to the capability of spectroscopy and dielectric properties in realizing in-line/on-line detection, applying spectroscopy and dielectric properties to explore the physical sensors which are

accurate, fast, cheap and time-saving, as well as could be used in-line/on-line detection will have great potential in future.

IV CONCLUSION

This review focuses on the rapid detection techniques, that is, chromatography, spectroscopy, dielectric properties and sensors, and main nutritional constituents, that is, fat, protein, lactose, mineral and vitamins, in milk. The applications of these techniques in detecting each main nutritional constituent are summarized in this study. The advantages and limitations of these techniques are discussed. There is much room for the development of accurate detection technology which is suitable for rapid detection of main nutritional constituents in milk. There is no such instruments is available that measures the all parameters at a time in a single device. There is also no such device that portable. There is also an urgent need for further researches to make commercial grade equipment could be used in situ and in-line/on-line detection on nutritional constituents of milk.

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