Application of Rapid Microbial Detection in Dairy Products

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Abstract: Dairy products are an indispensable part of people's daily life, but microbial contamination in dairy products poses a potential threat to consumer health. Traditional microbial detection methods have the disadvantages of long time and complex operation, which are difficult to meet the requirements of the dairy industry for fast, accurate, and efficient detection. This article reviews the application of rapid microbial detection technology in dairy products, aiming to provide reference for professionals in the dairy industry to ensure dairy product safety.

Keywords: Dairy Products; Microbial Detection; Rapid Detection; Safety Assurance

With the improvement of people's living standards, dairy products have become essential in daily life. However, the presence and proliferation of microorganisms in dairy products pose a potential threat to consumer health.[1] Traditional microbial detection methods are cumbersome and time-consuming, making it difficult to meet the dairy industry's demand for fast, accurate, and efficient detection. Therefore, the development and application of rapid microbial detection technology are of great significance to the dairy industry.

1. ATP Bioluminescence Method

The ATP detection method is a rapid, sensitive, and quantitative technique for microbial detection. ATP (Adenosine Triphosphate) is an energy molecule present in all living organisms and can therefore serve as an indicator of microbial presence. ATP is a high-energy molecule found in the cells of all living organisms. By measuring the ATP concentration in a sample, the existence and quantity of microorganisms can be indirectly reflected. There is a certain correlation between ATP and the quantity of microorganisms such as bacteria, fungi, and viruses. Therefore, ATP detection can be used to determine the microbial load in a sample. The main methods for ATP detection are bioluminescence and enzyme-coupled reactions.[2] Bioluminescence detection involves extracting ATP from the sample and reacting it with a fluorescent dye to form a fluorescent staining complex. The ATP concentration is then quantified by measuring the intensity of the fluorescence signal using a fluorescence detection device. Enzyme-coupled reactions involve reacting ATP in the sample with specific enzymes to produce measurable signals such as changes in absorbance or current, which are used to determine the ATP concentration. Each method has its advantages and disadvantages, and the choice of method depends on specific detection requirements and equipment conditions.[3]

The ATP detection method has many advantages. Firstly, it is a rapid detection method that can typically provide results within half an hour, much faster than traditional bacterial culturing methods. This is particularly important for applications requiring quick results, such as microbial detection in food processing and water quality monitoring. Secondly, the ATP detection method is quantitative, allowing for accurate measurement of ATP concentration and determination of microbial quantity. Additionally, ATP detection has a wide range of applications and can be used for different sample types, including liquids, solids, and surface materials.

However, the ATP detection method also has some limitations. Firstly, low-end ATP detection devices may have lower sensitivity and may not accurately detect low concentrations of ATP.[4] This may limit their application for samples with low microbial counts or for certain specific microbial detection tasks. Secondly, high-end ATP detection devices are costly and

may pose an economic burden for small businesses. Furthermore, ATP detection is susceptible to interference from factors such as ATP decomposition and the presence of cellular debris, which may affect the accuracy of the detection results.

Despite these limitations, the ATP detection method is still widely applied in many fields. In the food industry, ATP detection is used to detect and monitor microbial loads on products and surfaces, ensuring food safety and hygienic quality. In the brewing industry, ATP detection is used to detect microbial contamination during fermentation processes, guiding process control and quality assurance. In water quality monitoring, ATP detection can be used to assess microbial pollution levels and determine the sanitary safety of water. In the healthcare sector, ATP detection is used to monitor the cleaning and disinfection of surgical instruments, ensuring the sterility of the surgical environment.

2. Impedance Technology

Impedance technology is a commonly used microbial detection technique that is primarily based on the changes in microbial metabolism, impedance of the culture medium, and impedance of the double-layer electrode surrounding the electrode to determine the changes in M and E values, thereby determining the overall quantity of microorganisms. In addition, impedance technology can be used to cultivate specific types of bacteria by selecting specific culture media. Impedance technology has strong sensitivity and specificity, and exhibits advantages such as rapid response and repeatability. Compared to ATP fluorescence detection, impedance technology is relatively complex in microbial detection in dairy products. It requires the use of specific culture media and involves inoculation of bacteria. The impedance measurement instrument is used to obtain specific detection results once the bacteria reach the required concentration. However, impedance technology is more convenient when detecting raw milk or products approaching their expiration date. The time required to detect changes in the impedance value of the culture medium from the end of microbial inoculation is referred to as the detection time (DT). Research has found a certain correlation between the DT value and the logarithm of the initial concentration of microorganisms in the culture medium, indicating that a larger initial concentration of microorganisms leads to a smaller DT value, and vice versa.[5] Impedance technology requires a longer detection time when testing finished products and standardized semi-finished products. There are two main methods for applying impedance technology to the detection of dairy products: direct and indirect methods, with the indirect method primarily used in dairy product production processes. However, when using the direct method, the accuracy of measurement data is compromised due to unresolved issues related to impedance measurement interference from the sample.

Impedance technology is a commonly used microbial detection technique that holds significant application value in food safety and hygiene. Although impedance technology is slightly more complex than other detection methods when applied to microbial detection in dairy products, and it faces issues of sample interference in the direct method, its strong sensitivity, specificity, rapid response, and repeatability make it widely used in microbial detection in the food industry. In the future, further research and improvements can be made to impedance technology to enhance its accuracy and convenience in microbial detection in dairy products.

3. Flow Cytometry Rapid Measurement Technology

Microbial detection in dairy products is an important step in ensuring product quality and safety. In order to achieve cell detection, flow cytometry technology is widely used in this field. This technology can detect various parameters of cells and generate accurate results through data analysis. The advantage of flow cytometry technology is that it does not require sample culturing or preparation, thereby improving the practical level of dairy product testing. This makes the detection process more reliable and comprehensive. Currently, flow cytometry technology is widely applied in the actual detection of dairy products.[6] However, the use of flow cytometry requires a specialized flow cytometer, which is relatively expensive. In addition, the cost of staining reagents is also high. In practical applications, it is necessary to grasp the key points of technical operation and instrument maintenance, which poses certain technical requirements for companies. In addition to flow cytometry technology, flow cytometry rapid detection technology is also widely used.[7] This technology utilizes fluorescent labeling techniques to rapidly, sensitively, and accurately detect microorganisms. However, flow cytometry has a high initial investment, and sample handling and choice of fluorescent dyes can affect the detection results. In addition, the cost of equipment maintenance is

high, and operators need to have professional knowledge.[8] Despite these limitations, flow cytometry technology and flow cytometry rapid detection technology are still the most comprehensive, effective, and accurate methods in the field of microbial detection in dairy products. Relevant production companies need to consider economic strength and actual needs when choosing suitable detection techniques. In summary, flow cytometry technology plays an important role in microbial detection in dairy products. It can provide accurate and reliable detection results to help companies ensure product quality and safety.[9] Although it has a high investment cost and requires a certain level of technical skills, these limitations do not hinder the development of this technology. On the contrary, as technology continues to advance, flow cytometry technology will play a greater role in the dairy industry. Flow cytometry has a wide range of applications. In short, any cell or particle that can be labeled with fluorophores can be detected using a flow cytometer, especially for extremely small particles, its advantages of individual detection, sensitivity, speed, and multi-parameter analysis are more prominent.[10]

4. Conclusion

Dairy products are a highly important food category in the modern market, and the demand for dairy products continues to increase with the drive of economic development. However, the safety of dairy products has always been a significant concern, especially the microbial contamination that poses a major threat to their safety. Therefore, it is crucial to improve the accuracy and efficiency of microbial testing in dairy products. Traditional methods for detecting foodborne pathogens are complex, time-consuming, and require skilled technicians, which is not conducive to the cyclic production of dairy products. As a result, rapid microbial testing technologies have emerged and gained wide recognition and application. Different rapid microbial testing techniques have shown good performance in the field of dairy product testing, promoting the development of the dairy industry in China. With the increasingly strict food safety regulations in China, the safety monitoring of dairy products has become more important. By using rapid microbial testing technologies, it is more convenient and efficient to detect microbial contamination in dairy products, effectively enhancing their safety. This not only helps protect consumer health but also has significant impact on the reputation and market competitiveness of dairy product manufacturers.

References

[1] Fu Lihong, Cao Chuanni, Zhu Liting, et al. Issues and Countermeasures in Food Microbial Testing [J]. China Food Industry, 2023 (06): 32-33.

[2] Lian Yingzi, Jing Jing, Li Yue et al. A study on the rapid determination of total bacterial count in raw milk using ATP bioluminescence method [J]. Chinese Journal of Health Inspection, 2009,19 (04): 839-840

[3] Wang Shaolin. Detection of total bacterial count in food using electrical impedance method [J]. Journal of Jilin Grain College, 2002 (03): 13-18.

[4] Wu Huiqing, Wu Qingping, Zhang Jumei, et al. Comparative study on the detection of total viable bacteria in samples using bioluminescence detection and national standard method [J]. Food Industry Science and Technology, 2004 (04): 134-135+85.

[5] Zhang Ning. Analysis of Rapid Microbial Testing Technology for Dairy Products [J]. Technology Innovation and Application, 2016 (28): 294.

[6] Liu Daoliang, Zhao Zhanmin, Hu Lianxia, et al. Rapid detection of total bacterial count in liquid commodities using flow cytometry [J]. Food Science, 2011, 32 (02): 157-163.

[7] Zhang Fengli, Zhang Kui, Zhao Sanjun, etc.Metamorphosis of Magnetospirillum magneticum AMB-1 cells[J].Chinese Journal of Oceanology and Limnology, 2010, 28 (02): 304-309.

[8] Li Hua, Chang Ying. Working principle and clinical application of flow cytometry [J]. Information on medical devices in China, 2011, 17(05): 37-39+45.DOI:10.15971/j.cnki.cmdi.2011.05.002.

[9] Xie Xiaojun, Wang Chong, He Liang, et al. Study on counting bacteria by flow cytometry [J]. Journal of Microecology in China, 2009, 21 (06): 509-511.DOI:10.13381/j.cnki.cjm.2009.06.015.

[10] Liu Xinxing, Huo Zhuanzhuan, Yun Hui et al. Application of flow cytometry in rapid bacterial detection [J]. Microbiology Bulletin, 2014, 41 (01): 161-168.DOI:10.13344/j.microbiol.china.130041.