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Commentary

Thin-Layer Chromatography for the Rapid Screening of Antibiotic Residues in Food

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DESCRIPTION

Antibiotic residues in food, particularly in meat, dairy products, and aquaculture, pose significant concerns for public health. These residues arise from the improper or excessive use of antibiotics in livestock, often resulting in trace amounts of these compounds persisting in food products consumed by humans. The presence of antibiotic residues can lead to several negative consequences, such as allergic reactions, disruption of normal gut flora, and the growing issue of antibiotic resistance. Therefore, it is essential to develop sensitive, efficient, and rapid techniques for the screening of antibiotic residues in food products. Among the analytical techniques available, Thin-Layer Chromatography (TLC) stands out as a simple, cost-effective, and efficient method for detecting and identifying various compounds, including antibiotic residues. TLC provides quick results with minimal sample preparation, making it ideal for use in both laboratory and field settings. This manuscript explores the principles, methods, and applications of TLC for the rapid screening of antibiotic residues in food, highlighting its advantages, limitations, and future potential. Thin-Layer Chromatography (TLC) is a separation technique that relies on the differential affinity of compounds between a stationary phase (typically a thin layer of silica gel or alumina) and a mobile phase (a solvent or mixture of solvents. The compounds in the sample migrate at different rates depending on their polarity and affinity for the stationary and mobile phases, resulting in distinct separation.

TLC has been widely used to screen for various classes of antibiotic residues, including tetracyclines, sulfonamides, aminoglycosides, and beta-lactams. Detection and quantification can be achieved using various visualization techniques or densitometry. The sample preparation step is critical for the accurate detection of antibiotic residues. Typically, food samples such as meat, milk, or fish are homogenized and subjected to extraction procedures using solvents like methanol, acetonitrile, or ethyl acetate. After extraction, the samples may undergo further cleanup using Solid-Phase Extraction (SPE) to remove interfering substances, ensuring the selective detection of antibiotic residues. Common solvent systems for antibiotics include combinations of water, methanol, ethyl acetate, and ammonia, chosen based on the specific polarity and chemical properties of the antibiotic residues. Different antibiotics will migrate to different heights based on their interaction with the stationary and mobile phases, creating distinct spots for each compound.

Once the solvent has fully migrated, the TLC plate is dried and treated with a suitable visualization reagent. Depending on the antibiotic class, various visualization methods can be used. For instance, tetracyclines can be visualized under Ultraviolet (UV) light due to their natural fluorescence, while sulfonamides can be stained using diazotized reagents. Some antibiotics require more specific visualization techniques. For example, beta-lactam antibiotics are often detected using iodine vapor, which reacts with the beta-lactam ring, producing a visible spot. In cases where fluorescence or UV detection is insufficient, chemical derivatization of the plate may enhance the visibility of the antibiotic residues. While TLC is predominantly used as a qualitative method, it can be semi-quantitative when coupled with densitometry or image analysis software. By comparing the intensity of the antibiotic spots on the TLC plate with those of known standards, approximate concentrations of antibiotic residues can be determined. However, TLC generally has a higher Limit of Detection (LOD) compared to more advanced techniques such as Liquid Chromatography-Mass Spectrometry (LC-MS). Typical detection limits for antibiotics using TLC range from 10 to 100 µg/kg, depending on the specific antibiotic, food matrix, and visualization method.

CONCLUSION

Thin-Layer Chromatography offers a rapid, cost-effective method for screening antibiotic residues in food products. While it may not be as sensitive as more advanced chromatographic techniques, its simplicity and versatility make it a valuable tool for preliminary testing, especially in resource-limited settings. By enabling the rapid identification of potential contamination, TLC plays an important role in ensuring food safety and protecting public health from the risks associated with antibiotic residues.

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