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Study on detection methods for salbutamol in food and biological samples

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Abstract

Salbutamol is one of the β2-agonists used in human and veterinary medicine for the treatment of pulmonary disorders. It is also extensively misused in farm animals, where high doses give rise to a preferential muscle to fat ratio, resulting in financial gain for the farmer. This abundant misuse raised serious concerns about a toxicological risk for the consumer. Therefore, a rapid, simple, convenient, and effective method to monitor therapeutic use as well as to control the illegal use of salbutamol is essential. In this article the studies of detection methods for salbutamol in recent years are reviewed.

Keywords: salbutamol; β2-agonists; determination; detection; sensor.

1. Introduction

Salbutamol [2-(tert-butylamino)-1-(4-hydroxy-3-hyroxymethyl) phenylethanol], also known as albuterol, is β2-agonists, which works by relaxing the muscles and air passages in the lungs so that airflow becomes easier and improves breathing, which was originally developed for the clinical treatment of patients with asthma, bronchitis, emphysema and, in general, breathing diseases with bronchoconstriction [1-3]. The β2-agonist has a significant economic benefit in commercial meat production because it can enhance muscle growth and decrease fat deposition. Therefore, the β2-agonist has been illegally used as growth promoters in livestock animals [4-6]. However, the β2-agonist is easily deposited into the edible animal tissue, and the depositions in animal tissue can cause cardiovascular and other side effects to humans when the β2-agonist is administered at a dose higher than those required for therapeutic use. To guarantee the rights and interests of consumers, the fast and effective analysis of the β2-agonist in the meat industry is of utmost importance [7-9]. In this paper, the attributes of different analytical technique for the determination of salbutamol in recent years are reviewed.

2. Analytical Methods

2.1. HPLC method. High-performance liquid chromatography (HPLC) is a powerful tool that enables the separation of complex mixtures into individual components, and is a highly sensitive and reproducible analytical technique. In recent years, HPLC has been combined with many sensitive detection techniques and has experienced continuous improvement of stationary phases, which have improved its sensitivity and specificity. HPLC is currently widely used for the analysis of drugs and dosage forms with respect to quality control, quantitative determination of active ingredients and impurities, monitoring drug blood concentration in patients, and bioequivalence assessment [10-12].

Zhang *et al.* [13] developed and validated a sensitive and selective liquid chromatography coupled to tandem mass spectrometry for the determination of salbutamol in human plasma and urine. Salbutamol and the internal standard acetaminophen in plasma and urine were extracted with ethyl acetate, separated on a C18 reversed-phase column, eluted with mobile phase of acetonitrile–ammonium acetate, ionized by positive ion pneumatically assisted electrospray and detected in the

multi-reaction monitoring mode. The lower limits of quantitation of salbutamol in human plasma and urine by this method were 0.02 and 1 ng/mL, respectively. In conclusion, the validation results showed that this method is robust, specific and sensitive, and could successfully fulfill the requirement of clinical pharmacokinetic study of salbutamol in healthy Chinese volunteers.

Guo *et al.* [14] developed a rapid, selective and sensitive liquid chromatography–tandem mass spectrometry assay method for simultaneous determination of ambroxol and salbutamol in human plasma using citalopram hydrobromide as internal standard. The sample was alkalinized with ammonia water and extracted by single liquid–liquid extraction with ethyl acetate. Separation was achieved on Waters Acquity UPLC BEH C18 column using a gradient program at a flow rate of 0.2mL/min. Detection was performed using electrospray ionization in positive ion multiple reaction monitoring mode by monitoring the ion transitions. Calibration curves were linear in the concentration range of 0.2–20.0ng/mL for salbutamol. The method was successfully applied in a clinical pharmacokinetic study of the compound ambroxol and salbutamol tablets.

2.2. Electrochemical method. Since the early 70s electrochemistry has been used as a powerful analytical technique for monitoring electroactive species in living organisms. Electrochemical methods are the preferred methods for the detection of β-agonists, because most of the β--agonists can be oxidized at bare or modified electrodes [15-17].

Zou *et al.* [18] deposited a composite Langmuir_Blodgett film prepared from DNA and polyaniline on the surface of a glassy carbon electrode to give a new voltammetric sensor for the β2-agonist salbutamol. They employed cyclic voltammetry and electrochemical impedance spectroscopy to study the characteristic of the modified electrode. They investigated the electrochemistry of salbutamol at the modified electrode at pH 6.8 by cyclic voltammetry and differential pulse anodic voltammetry. The oxidation of salbutamol at this electrode was an adsorption-controlled irreversible process. They worked out a sensitive electroanalytical method that displayed high precision and good reproducibility for the determination of salbutamol. The method was applied to quantify salbutamol in tablets with satisfactory results.
Attaran *et al.* [19] introduced a fast and direct electrochemical method for the determination of salbutamol using an iron titanate nanopowder-modified carbon paste electrode. The electrochemical behavior of salbutamol was studied by differential pulse adsorptive stripping voltammetry. Factors affecting the performance of the adsorptive stripping such as the modifier percent, the electrolyte pH and accumulation time and potential were optimized. The resulting electrode exhibited a linear response in the range of 0.2–25 nM of salbutamol with a detection limit of 90 pM. The proposed method was successfully applied to determine salbutamol in pharmaceutical formulations and human blood plasma.

2.3. Capillary electrophoresis method. In recent decades, capillary electrophoresis (CE) has been developed for trace analysis because of its small sample size of only nanoliters to femtoliters, short analysis time, and biocompatible environments. In addition, rapid separations are feasible with CE because high voltages can be applied to short capillaries and separation efficiency is not dependent on column length. To identify biological and pharmaceutical analysis, CE is coupled to a variety of detectors, including fluorescence, mass spectrometry, and electrochemical detection [20,21].

Bao *et al.* [22] developed a capillary electrophoresis coupled with tris(2,2'-bipyridyl) ruthenium(II) electrochemiluminescence detection system to determine salbutamol and clenbuterol in urine. They investigated some factors that affected the performances of separation and detection. Under the optimized conditions, one single quantitative analysis of salbutamol and clenbuterol was achieved at a separation voltage of 15 kV within 9 min, and the LODs (S/N=3) and LOQs (S/N=10) of salbutamol and clenbuterol were 8.43×10^{-8} mol/L, 2.61×10^{-7} mol/L and 2.73×10^{-7} mol/L, 8.21×10^{-7} mol/L, respectively. The recovery obtained from the analysis of spiked urine samples was between 88.6% and 104.7% with RSDs lower than 6.70%. The method was successfully applied to determine salbutamol and clenbuterol in urine samples.

Fan *et al.* [23] developed the sensitive determination of clenbuterol and salbutamol in swine urine by using CE with a moving reaction boundary-based stacking method. Under the optimum conditions, the moving reaction boundary-based stacking procedure produced an improved concentration sensitivity of 70.5-fold for clenbuterol and 24.7-fold for salbutamol. The improvement resulted in a limit of detection of about 0.26 ng mL^{-1} and 0.96 ng mL^{-1} for clenbuterol and salbutamol, respectively. The method has been successfully used for the analysis of clenbuterol and salbutamol in swine urine, and the RSD was less than 5.0%, the recoveries were in the range of 96.8–103.6% and the linear ranges of clenbuterol and salbutamol were 0.003–10.0 mg mL^{-1} and 0.01–20.0 mg mL^{-1}, respectively.

2.4. Other methods. In addition to these main approaches mentioned above for salbutamol detection, still a few special techniques with high sensitivity have been applied. Yan *et al.* [24] developed a label-free immunosensor for the determination of salbutamol based on localized surface plasmon resonance biosensing. Tang *et al.* [25] reported the determination of salbutamol using R-phycoerythrin immobilized on eggshell membrane surface as a fluorescence probe. Samir *et al.* [26] reported the development and validation of simultaneous spectrophotometric and TLC-spectrodensitometric methods for the determination of

beclomethasone dipropionate and salbutamol in combined dosage form. Chai *et al.* [27] designed the development of a portable sensor based on a molecularly imprinted membrane for the rapid determination of salbutamol in pig urine.

3. Conclusions

Salbutamol is extensively used as a bronchodilator in asthmatic patients. However, the illegal use of salbutamol as growth-promoting agents in animals is still a public concern due to its potential risk to the health of individuals consuming animal products contaminated with the residue of β2-agonists [28-30]. Thus, it is necessary to establish quick and accurate methods to detect salbutamol residues. This review has highlighted the significant developments in rapid and alternative techniques for the detection of salbutamol in recent years. We believe the development of salbutamol sensors with better sensitivity and specificity, lower cost, simplicity, along with in vivo analytical technique is still the future effort.

Acknowledgments

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References

[1] Althanyan MS, Clark BJ, Hanaee J, Assi KH. Development of a microemulsion high performance liquid chromatography (MELC) method for determination of salbutamol in metered-dose inhalers (MDIS), BioImpacts 2013; 3(1):37–42.

[2] Mokhtari B, Pourabdollah K. Preparation and characterization of bonded-phases of calixarene-sulfonyl-carboxamides in partial-cone conformation for determination of salbutamol in livestock by nano-mediated bonded-phases: nano-baskets of calixarene in partial-cone conformation, J Chil Chem Soc 2012; 57(2):1150−1154.

[3] Qu CH, Li XL, Zhang L, Xi CX, Wang GM, Li NB *et al*. Simultaneous determination of cimaterol, salbutamol, terbutaline and ractopamine in feed by SPE coupled to UPLC, Chromatographia 2011; 73(3-4):243-249.

[4] Li C, Wu YL, Yang T, Zhang Y, Huang-Fu WG. Simultaneous determination of clenbuterol, salbutamol and ractopamine in milk by reversed-phase liquid chromatography tandem mass spectrometry with isotope dilution, J Chromatogr A 2010; 1217(50):7873-7877.

[5] Wu JW, Ding CG, Ge QH, Li Z, Zhou Z, Zhi XJ. Simultaneous determination of ipratropium and salbutamol in rat plasma by LC-MS/MS and its application to a pharmacokinetic study, J Chromatogr B 2011; 879(30):3475-3483.

[6] Zhou T, Zeng J, Liu S, Zhao T, Wu J, Lai WS *et al*. Study on the determination and chiral inversion of R-salbutamol in human plasma and urine by liquid chromatography-tandem mass spectrometry, J Chromatogr B 2015; 1002:218-227.

[7] Zhou YL, Zhang HQ, Chang Z, Ye BX, Xu MT. Simultaneous determination of clenbuterol and salbutamol with a graphene-nafion nanocomposite modified electrode, Int J Electrochem Sci 2016; 11(6):5154-5164.

[8] Wei YL, Zhang Q, Shao C, Li C, Zhang LP, Li XL. Voltammetric determination of salbutamol on a glassy carbon electrode coated with a nanomaterial thin film, J Anal Chem 2010; 65(4):398-403.

[9] Sanchez MA, Rocha FRP. A flow-based analytical procedure for salbutamol determination exploiting chemiluminescence in a liquid-core waveguide, Anal Lett 2008; 41(9):1579-1591.

[10] Yang Y, Rosales-Conrado N, Guillen-Casla V, Leon-Gonzalez ME, Perez-Arribas LV, Polo-Diez LM. Chiral determination of salbutamol, salmeterol and atenolol by two-dimensional LC-LC: application to urine samples, Chromatographia 2012; 75(23-24):1365–1375.

[11] Mareck U, Guddat S, Schwenke A, Beuck S, Geyer H, Flenker U *et al*. Determination of salbutamol and salbutamol glucuronide in human urine by means of liquid chromatography-tandem mass spectrometry, Drug Test Anal 2011; 3(11-12): 820–827.

[12] Rosales-Conrado N, Dell'Aica M, de Leon-Gonzalez ME, Perez-Arribas LV, Polo-Diez LM. Determination of salbutamol by direct chiral reversed-phase HPLC using teicoplanin as stationary phase and its application to natural water analysis, Biomed Chromatogr 2013; 27(11):1413–1422.

[13] Zhang DJ, Teng YN, Chen KG, Liu S, Wei CM, Wang BJ *et al*. Determination of salbutamol in human plasma and urine using liquid chromatography coupled to tandem mass spectrometry and its pharmacokinetic study, Biomed Chromatogr 2012; 26(10):1176–1182.

[14] Guo ZN, Chen YS, Ding XL, Huang CR, Miao LY. Simultaneous determination of ambroxol and salbutamol in human plasma by ultra-performance liquid chromatography-tandem mass spectrometry and its application to a pharmacokinetic study, Biomed Chromatogr 2016; 30(11):1789–1795.

[15] Goyal RN, Kaur D, Singh SP, Pandey AK. Effect of graphite and metallic impurities of C-60 fullerene on determination of salbutamol in biological fluids, Talanta 2008; 75(1):63-69.

[16] Goyal RN, Oyama M, Singh SP. Fast determination of salbutamol, abused by athletes for doping, in pharmaceuticals and human biological fluids by square wave voltammetry, J Electroanal Chem 2007; 611(1-2): 140-148.

[17] Lin KC, Hong CP, Chen SM. Simultaneous determination for toxic ractopamine and salbutamol in pork sample using hybrid carbon nanotubes, Sens Actuator B-Chem 2013; 177:428–436.
[18] Zou LA, Li YF, Cao SK, Ye BX. A glassy carbon electrode modified with langmuir-blodgett film composed of DNA and polyaniline for the sensitive determination of salbutamol, Electroanalysis 2014; 26(5):1051–1058.
[19] Attaran AM, Javanbakht M, Fathollahi F, Enhessari M. Determination of salbutamol in pharmaceutical and serum samples by adsorptive stripping voltammetry on a carbon paste electrode modified by iron titanate nanopowders, Electroanalysis 2012; 24(10):2013–2020.
[20] Loden H, Pettersson C, Arvidsson T, Amini A. Quantitative determination of salbutamol in tablets by multiple-injection capillary zone electrophoresis, J Chromatogr A 2008; 1207(1-2):181-185.
[21] Chen CG, Li H, Fan YJ. Determination of salbutamol sulfate in medicaments by capillary electrophoresis with contactless conductivity detection, Chinese journal of chromatography 2011; 29(2):137–140.
[22] Bao Y, Yang F, Yang XR. Capillary electrophoresis coupled with electrochemiluminescence for the facile separation and determination of salbutamol and clenbuterol in urine, Electroanalysis 2012; 24(7):1597–1603.
[23] Fan LY, Chen Q, Zhang W, Cao CX. Sensitive determination of illegal drugs of clenbuterol and salbutamol in swine urine by capillary electrophoresis with on-line stacking based on the moving reaction boundary, Anal Methods 2013; 5(11):2848-2853.
[24] Yan ZR, Hu TT, Guo WY, Deng AP, Di JW. A label-free immunosensor for determination of salbutamol based on localized surface plasmon resonance biosensing, Bioprocess Biosyst Eng 2014; 37(4):651-657.
[25] Tang JL, Liu ZS, Kang J, Zhang YH. Determination of salbutamol using R-phycoerythrin immobilized on eggshell membrane surface as a fluorescence probe, Anal Bioanal Chem 2010; 397(7):3015-3022.
[26] Samir A, Lotfy HM, Salem H, Abdelkawy M. Development and validation of simultaneous spectrophotometric and TLC-spectrodensitometric methods for determination of beclomethasone dipropionate and salbutamol in combined dosage form, Spectroc Acta Pt A-Molec Biomolec Spectr 2014; 128(1):127-136.
[27] Chai CY, Liu GY, Li F, Liu XF, Yao B, Wang L. Towards the development of a portable sensor based on a molecularly imprinted membrane for the rapid determination of salbutamol in pig urine, Anal Chim Acta 2010; 675(2):185-190
[28] Wu YP, Xu F, Jiang HY, Tao XQ, Zhu K, Liu WL *et al*. Determination of salbutamol, clenbuterol, and brombuterol in urine by a highly sensitive chemiluminescence enzyme immunoassay, Anal Lett 2014; 47(16):2761-2773.
[29] Wu YY, Shi WX, Chen SQ. Determinat ion of β-estradiol, bisphenol A, diethylstilbestrol and salbutamol in human urine by GC/MS, Journal of zhejiang university (medical sciences) 2009; 38(3):235-241.
[30] Pleadin J, Vulic A, Persi N, Terzic S, Andrisic M, Zarkovic I. Rapid immunoassay method for the determination of clenbuterol and salbutamol in blood, J Anal Toxicol 2013; 37(4):241-245.

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