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CHINA FOOD SAFETY: MEETING THE CHALLENGES OF CLENBUTEROL

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Food poisoning cases, due to consumption of food from animal sources that contains clenbuterol, have occurred frequently in China over the recent years, causing a certain degree of social panic. Several relevant ministries issued related documentation and took appropriate measures to crack down on the behaviour of illegal manufacture, sale, and use of clenbuterol. However, this behaviour continued due to great economic benefits and ethical problems. This paper investigates the industrial chain of production and sale of clenbuterol in China. Moreover, we discuss the impediments of and the governmental countermeasures being implemented in supervising the use of clenbuterol in China. The positive example in monitoring the use of clenbuterol in China may help to improve food safety management throughout China and other developing countries.

Keywords: clenbuterol, food safety, China, impediments, countermeasures

In recent years, a series of food safety scandals have occurred in China, such as clenbuterol in pork, melamine in dairy products, counterfeit baby formula, Sudan I red dye, problem capsules, exploding watermelons, pesticide-tainted vegetables, pork reconstituted as beef, plasticizer in drinks and trench oil on dining tables (Shao, 2013; Lu & Wu, 2014). Unchecked intoxicants may be highly relevant to the health of future generations and in the developing countries context may present a number of specific scenarios following exposure to pollutants (Frazzoli et al., 2009). The Chinese government still faces serious problems in ensuring food safety, although China has made great progress on that field (Wu et al., 2010). China is a major food importer, producer and consumer country accounting for almost 20% of the world's population. Types of meals and consumption patterns vary from country to country and are influenced by national and/or regional food cultures (Ohiokpehai, 2003). Indeed, China's food safety has become an international issue.

Over ten large-scale incidents of clenbuterol poisoning have happened since 1998 in China, and about 4000 people were poisoned (Guan & Meng, 2013). Clenbuterol is a growth-promoting drug in the beta-agonist class of compounds, which can act on adrenergic receptors selectively and cause sympathetic nerve disfunctions. A dose of 3–5 mg kg^{-1} of clenbuterol in pig feed can make a 9.7% increase of lean meat, and a 14.1% decrease of fat (Zhou et al., 2009). It is called a "nutrition redeployment agent" for the effect of growth-promotion. Its presence in any form of food is illegal and may cause many harmful effects to humans, such as inducing malignancies, chromosomal aberrations, metabolic disorders, hypokalemia, and other acute types of poisoning (Zhang, 2012). Clenbuterol residues can affect lung and heart function in persons, who have eaten liver or meat of drugged animals (Wennig, 1996). The

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Food and Drug Administration (FDA) prohibits the sale of clenbuterol to be given to any animal that could be used as food for human consumption in the U.S.

A total of 309 illegal cases of addition of clenbuterol were investigated by animal husbandry and veterinary departments in China: 2013 – A bulletin published by The Ministry of Agriculture of The People's Republic of China (MAPRC, 2014). Chinese consumers were panicked by the announcement that clenbuterol was detected in food from animal sources, which reduced confidence in food safety in China and also had a huge impact on the credibility of the Chinese government and its international image. The relevant Chinese government departments needed to establish a comprehensive monitoring and implementation system for clenbuterol.

This study analysed the industrial chain for the production and sale of clenbuterol in China and the impediments and countermeasures being implemented in the supervision of this industry.

1. Materials and methods

1.1. What is clenbuterol

Clenbuterol is a white or almost white crystalline powder, odourless, bitter tasting, soluble in water and alcohol. It is considered a good candidate for the treatment of muscle disuse (Sirvent et al., 2014) and might increase mass of the sartorius muscle by decreasing myostatin gene expression and protein degradation (Ijiri et al., 2014). It was used for the treatment of asthma, but it is neither a veterinary drug nor feed additive. Clenbuterol has been used to alleviate chronic obstructive pulmonary disease and elicits an anabolic response in muscles, and perturbation in neuromuscular communication, treatment with clenbuterol could improve muscle mass (Lang et al., 2014). Clenbuterol can promote protein synthesis in the growth process of fattening pigs and make fat convert to lean meat. In the past 10 years, a number of elite athletes have used clenbuterol as a performance-enhancing drug, leading to its ban by The International Olympic Committee and World Anti-doping Agency (WADA, 2011).

Clenbuterol is a medical drug that is used as a feed additive to promote leanness in livestock raised for their meat (especially pigs) in recent years in China. It is a β2-adrenergic agonist with a long half-life of around 25–40 h and high bio-availability (Couet et al., 1989). Therefore, a large dose of clenbuterol is present in the livestock's system for a long time with unlimited feeding and sluggish metabolism. The chemical properties of clenbuterol are relatively stable, it will not decompose completely even with cooking at high temperature (50% decomposition rate at 126 °C for 5 min) (Shen et al., 2012). Those, who ingested edible meat tainted with clenbuterol residue, suffer from headache, nausea, electrolyte imbalance, muscle tremors, and other heart diseases (Zhang, 2012). It is prohibited to add clenbuterol to livestock feed in the U.S., EU countries, and China.

1.2. Clenbuterol incidents and underground production and sale in China

China Central Television (CCTV) reported that pig farms use the prohibited animal drug clenbuterol to breed pigs in Mengzhou, Henan Province on March 15, 2011, the day of The International Day for Protecting Consumers' Rights. What is more, the pork containing clenbuterol was sold to Shuanghui Food Co., Ltd., which is a large international food group, mainly engaged in meat processing; it is also the largest in China and the world's leading supplier of meat. The related pig farms, pig feed, and the regulatory authorities were

thoroughly inspected. From March 15th to 23rd, 60 thousand large-scale pig farms and 70 thousand individual small-scale pig farmers were inspected one by one, 134 pigs and several batches of pig feed were confirmed to contain clenbuterol. Consumers were in "panic" and reduced purchase of pork, which caused a short-term national pork price decrease. China was also blacklisted by the Union of European Football Associations (UEFA) due to clenbuterol incidents. The Food Safety Commission Office of the State Council is carrying out a special nationwide crackdown on clenbuterol issues to ensure food safety.

In China, an industrial chain "from industrial material to dining table" of clenbuterol production has been established (Fig. 1). The main process is as follows: 1) Purchasing of raw materials and production machinery. Illegal producers purchase raw materials and rent an abandoned factory in the name of producing legitimate chemicals. The main chemical raw materials include C_2H_6O, KBH_4, $NaHCO_3$, DMF, HCl, and other chemicals. Production machines are easy to find in conventional chemical production workshops. 2) Manufacturing in underground factory. A series of chemical reactions are done in reactors to produce clenbuterol end products. Illegal producers have experience in clenbuterol manufacture and have chemical knowledge, and it is easy for them to manufacture clenbuterol in secret. 3)

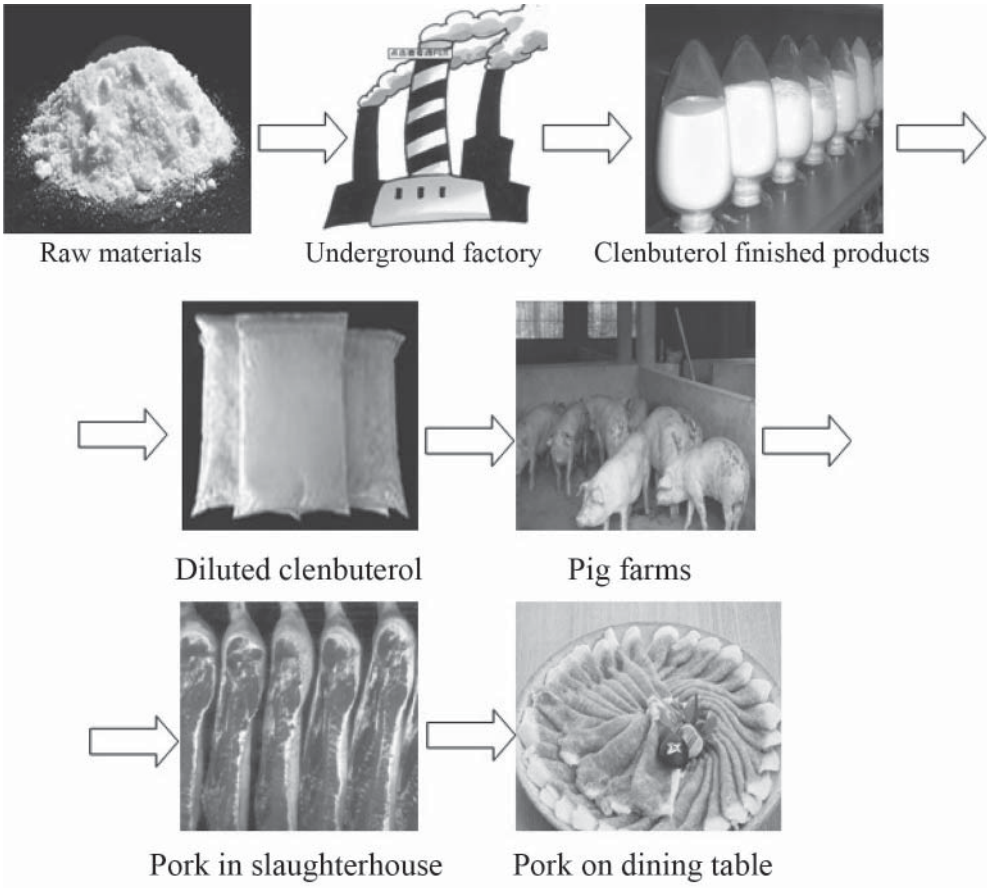

Fig. 1. The industrial chain of production and sale of clenbuterol in China

Dilution with starch by middlemen. The middleman purchases clenbuterol end products and dilutes 30–35-fold with starch to make a big profit. 4) Selling to feeder. Clenbuterol dilution was sold to pig feeders at relatively constant market prices. 5) Feeding to pigs. Pig feeders mix clenbuterol into pig food to feed pigs but the dose of mixed clenbuterol is casual. 6) Selling the pork. The pork is wholesaled from hog processing slaughterhouses then transported to various markets. 7) Clenbuterol on the dining table. Consumers buy the pork containing clenbuterol residues that may cause physical discomfort.

2. Results and discussion

2.1. Impediments in the supervision of clenbuterol

2.1.1. Driven by economic interests. The price of raw materials of clenbuterol is 245 Euros per kg and the profit of finished products is 74–86 Euros. The price of diluted clenbuterol is 12–20 Euros per kg, the profit is over 500%. When pig farmers feed clenbuterol to pigs in late rearing, 10–12 Euros cost can make a net profit of 24–31 Euros, the average profit margin is 250% (He, 2012). The pigs feeding on clenbuterol have nice bodies, thick hind legs, high lean meat, and bright flesh. These porks are welcomed by consumers who have no idea about clenbuterol. Therefore, in the absence of effective regulation, some pharmaceutical manufacturers, farming enterprises, feeders, pork operators, and slaughtering enterprises take the risk to reap greater benefits.

2.1.2. Unsound supervision and regulatory system

2.1.2.1. Inadequate supervision. At present, the main clenbuterol supervision locations include pig farms and slaughterhouses, and random sampling tests mainly related to pig feed, urine, offal, and meat. However, the high cost of sampling tests (urine test at 12 Euros per sample, more than 180 thousands Euros per animal for offal residue detector) and long detection time are responsible for the low detection rate (about 1–5%). There are more than 67 million pig farmers, 31.5% of these have over 500 pigs, and the number of slaughtered pigs amounts up to 600 million per year in China (He, 2012). Furthermore, the free trade hog markets and multiple other locations where port meat can be acquired cause detection loophole and supervision difficulty.

2.1.2.2. High cost and low efficiency of supervision versus *low cost of illegal behaviour.* "Sectional management" mode was implemented in food production and distribution in China, and food management refers to several laws and management departments. Food regulation seemingly has spectacular majesty, but the regulatory objects are of large quantity, small-scale with scattered distribution, and the regulatory mechanisms are dysfunctional, so the supervision efficiency is low and the supervision cost is high. Supervision departments seldom identify problems pro-actively in clenbuterol food safety incidents, and always lag behind the news media, cases of complaints, or safety incidents.

High cost and low efficiency of supervision and the high cost of consumer rights defence against the low cost of domestic illegal businesses make a fundamental solution of food safety almost impossible. Some local governments might consider the sensitivity of food safety and tend to protect local industries. Therefore, illegal operators always get light punishment and food safety incidents are turned to "internal process".

2.1.2.3. Convergence enforcement loopholes. The multiple management system of food safety caused the repeated emergence of clenbuterol. Although the law emphasizes the responsibilities of different departments, the food safety supervision system in China is based on a segmented supervision model, which overlaps and inter-crosses at different departments, so supervision is ineffective (Wang et al., 2009; Jia & Jukes, 2013). In the whole clenbuterol industry chain in China, animal husbandry and veterinary departments were responsible for the management of raising livestock and farming feed, and the department of drug administration, quality administration, and business administration were responsible for drug manufacturers and chemical companies. There are many missing links in the regulation of pig feeding, slaughter, processing, and sale.

2.2. Countermeasures to enhance the management of clenbuterol in China

2.2.1. Strengthening social ethics and legal awareness education. Society must supervise and all stakeholders must be educated in the human food chain (FAO & WHO, 2003). An important factor of clenbuterol incidents is the low moral quality and legal awareness of people of the clenbuterol industry chain. Therefore, the focus of government departments is not only supervision and management but also social ethics and legal awareness education. It is necessary to carry on the extensive publicity by TV, radio, internet, newspaper, posters, lectures, and expert reports, enabling the public to know features and hazards of clenbuterol in pork.

2.2.2. Strengthening government supervision

2.2.2.1. Strengthening accountability. The safety supervision of the hog industry should be brought into the government target management system, and establish corresponding evaluation mechanisms. Implementing the responsibility of government at all levels in the safety supervision of livestock products, and clarifying and strengthening the principles especially for the persons responsible, are of high importance. Establishing a safety assessment system and implementing safety accountability of livestock products are also important. In accordance with the law, serious accountability and punishment should be employed to whom dereliction of duty applies in the safety of livestock product management. Strengthened efforts are needed to combat and investigate delinquent behaviour in clenbuterol production, sale, and feed.

2.2.2.2. Intensifying efforts for detection. A detection system combined with self-testing by farming enterprises and sampling inspection by the regulatory authorities should be established and improved. Sensitive and rapid detection methods, such as electrochemical immunosensor (Yang et al., 2014), glassy carbon electrode (Wang et al., 2014), and surface molecularly imprinted polymers (Du et al., 2014), should be used to trace clenbuterol in real samples. Detection departments can trace the origin of pork quickly by identifying two-dimensional coding, which is affixed to the pork.

2.2.2.3. Investing more funds. Effective supervision of clenbuterol needs a lot of invested funds. Therefore, a livestock security special fund should be part of the public finances and included into the fiscal budget by governments at all levels.

2.2.2.4. Strict law enforcement and supervision. Law enforcement is a key to China's food safety (Ni & Zeng, 2009). China has enforced laws and regulations and reformed the

food-safety management system for clenbuterol. Various regulatory departments should further clarify the division of responsibilities and strengthen communication and coordination to combat crimes of clenbuterol incidents together.

2.2.3. Establishing and improving public report and public oversight system. The Chinese government encourages the general public and media to supervise the food safety situation by establishing an offence reporting system. Establishment of an efficient, convenient, and security reporting oversight system with public participation is needed. First, dedicated hot-lines for livestock safety oversight agencies should be introduced to the whole society. Secondly, special agencies should be established to be in charge of dealing with report messages and to ensure that the system is institutionalized and standardized. Thirdly, strict secrecy should be provided to eliminate the concerns of the masses and to build reporter confidence. Fourthly, a reward system should be established. Informants should get proper rewards for helping to solve the problems of clenbuterol food safety. Fifthly, the facts of clenbuterol illegal behaviour should be presented to the public to increase social pressure on illegal business and personnel, and also to raise awareness.

3. Conclusions

Clenbuterol is not only a threat to people's health but also has enormous impact on the development of the domestic food industry, consumer confidence, government credibility, and the international image of China. Therefore, it is necessary to eliminate clenbuterol thoroughly to ensure food safety in China. There are many aspects to the use of clenbuterol and many government departments are involved in clenbuterol management. The reasons behind clenbuterol incidents are economic interest, moral dimensions, practices in legislation and law enforcement. By investigating the industrial chain of production, marketing, and use of clenbuterol, each aspect should receive intense attention to be able to destroy clenbuterol little by little.

Enforcing food safety laws and strengthening food safety supervision are the keys to food safety in China. The use of clenbuterol has exposed the weak links of food safety assurance systems in the country. However, the response of the Chinese government to this problem is rapid and effective. The government departments are showing a positive attitude towards the clenbuterol situation; they have enforced food safety laws and regulations, and reformed management systems to control the spread of this non-food item, to improve food safety. The experience of clenbuterol management in China may help to improve food safety supervision in other developing countries and regions.

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References

Couet, W., Girault, J., Reigner, B.G., Ingrand, I., Bizouard, J., Acerbi, D., Chiesi, P. & Fourtillan, J.B. (1989): Steady-state bioavailability and pharmacokinetics of ambroxol and clenbuterol administered alone and combined in a new oral formulation. *Int. J. Clin. Pharmacol. Ther. Toxicol., 27*, 467–472.

Du, W., Lei, C., Zhang, S., Bai, G., Zhou, H., Sun, M., Fu, Q. & Chang, C. (2014): Determination of clenbuterol from pork samples using surface molecularly imprinted polymers as the selective sorbents for microextraction in packed syringe. *J. Pharmaceut. Biomed, 91,* 160–168.

FAO & WHO (2003): Assuring food safety and quality: guidelines for strengthening nation food control systems. Available at: http://www.fao.org/docrep/006/y8705e/y8705e00.htm. (Last accessed: 25 October 2014)

Frazzoli, C., Petrini, C. & Mantovani, A. (2009): Sustainable development and next generation's health: a long-term perspective about the consequences of today's activities for food safety. *Ann. I. Super. Sanita.*, *45*(1), 65–75.

Guan, E.P. & Meng, G.X. (2013): *Metabolic analysis and security control of clenbuterol in pig.* China Agricultural Science and Technology Press. (Monograph in Chinese). 92 pages.

He, P.H. (2012): Cause and governance of illicit drug abuse from perspective of risk cost — A case study in supervision of clenbuterol. *J. Huazhong Agric. Uni. (Social Sciences Edition)*, *98,* 64–71. (Article in Chinese).

Ijiri, D., Ishitani, K., Shimamoto, S., Ishimaru, Y. & Ohtsuka, A. (2014): The effects of intraperitoneal clenbuterol injection on protein degradation and myostatin expression differ between the sartorius and pectoral muscles of neonatal chicks. *Gen. Comp. Endocr., 206,* 111–117.

Jia, C. & Jukes, D. (2013): The national food safety control system of China – A systematic review. *Food Control, 32*, 236–245.

Lang, G., Dernoncourt, V. & Bisson, J.F. (2014): Negative effect of clenbuterol on physical capacities and neuromuscular control of muscle atrophy in adult rats. *Muscle nerve*. DOI: 10.1002/mus.24273

Lu, F. & Wu, X. (2014): China food safety hits the "gutter". *Food Control, 41,* 134–138.

MAPRC (2014): Ministry of Agriculture of People's Republic of China, Bulletin. Clenbuterol special rectification remarkable. Available at: http://www.moa.gov.cn/zwllm/zwdt/201401/t20140103_3730605.htm. (Article in Chinese).

Ni, H.G. & Zeng, H. (2009): Law enforcement is key to China's food safety. *Environ. Pollut., 157*, 1990–1992.

Ohiokpehai, O. (2003): Nutritional aspects of street foods in Botswana. *Pak. J. Nutr., 2(*2), 76–81.

Shao, Y. (2013): Rethinking food safety problems in China. *Acta Alimentaria, 42*, 124–132.

Shen, R.H., Hu, S.L., Hu, L.Q. & Zhang, Y.L. (2012): Discussion regulatory of clenbuterol. *China Animal Healthcare, 12*(14), 4–7. (Article in Chinese).

Sirvent, P., Douillard, A., Galbes, O., Ramonatxo, C., Py, G., Candau, R. & Lacampagne, A. (2014): Effects of chronic administration of clenbuterol on contractile properties and calcium homeostasis in rat extensor digitorum longus muscle. *PloS one, 9*(6), e100281.

WADA (2011): World Anti-Doping Agency. Statement on clenbuterol. https://www.wada-ama.org/en/media/2011-06/wada-statement-on-clenbuterol#.VDOsRfmSyuc (Last accessed: 25 October 2014).

Wang, L., Yang, R., Chen, J., Li, J., Qu, L. & de B Harrington, P. (2014): Sensitive voltammetric sensor based on Isopropanol–Nafion–PSS–GR nanocomposite modified glassy carbon electrode for determination of clenbuterol in pork. *Food Chem*., *164,* 113–118.

Wang, S., Zhu, H., Ge, Y. & Qiao, H. (2009): Current status and management of chemical residues in food and ingredients in China. *Trends Food Sci. Tech., 20*(9), 425–434.

Wennig, R. (1996): Laboratory diagnosis of poisonings. -in: Descotes, J. (Ed.) *Human toxicology*. Elsevier, Amsterdam, the Netherlands, pp. 25–236.

Wu, X., Wu, H., Xia, L., Ji, K., Liu, Z., Chen, J., Hu, D., Gao, C. & Wu, Y. (2010): Socio-technical innovations for total food chain safety during the 2008 Beijing Olympics and Paralympics and beyond. *Trends Food Sci. Tech., 21*(1), 44–51.

Yang, X., Wu, F., Chen, D.Z. & Lin, H.W. (2014): An electrochemical immunosensor for rapid determination of clenbuterol by using magnetic nanocomposites to modify screen printed carbon electrode based on competitive immunoassay mode. *Sensor Actuat. B- Chem., 192*, 529–535.

Zhang, X. (2012): Food safety supervision and administration of clenbuterol. *Chinese Primary Health Care, 26*(6), 46–47. (Article in Chinese).

Zhou, S.D., Lu, P.J., Li, Y.W. & Li, G.H. (2009): Hazards and control measures pig "lean" residual. *Guangdong J. Anim. Vet. Sci., 34*(4), 29–31. (Article in Chinese).