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Quantifying the Prevalence of Salbutamol Residues in Pork Meat: Implications for Consumer Health

Supakorn Nitisiri[1], Phoodit Saokleaw[2], Shopan Panakul[3], Prima Ongwanich[4], Nawaphorn Tanatiratorn[5]
[1]KIS International School , Bangkok , 10310, Thailand
[2]Princess Chulabhorn Science High School Chonburi , Chonburi , 20170, Thailand
[3]Ekamai International School, Bangkok , 10110, Thailand
[4]Mahidol University International Demonstration School , Nakhon Pathom , 73170, Thailand
[5]Srinakharinwirot University Prasarnmit Demonstration School (Secondary) , Bangkok , 10110, Thailand

***Corresponding Author:**
Supakorn Nitisiri
KIS International School , Bangkok , 10310, Thailand

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Abstract

Introduction: Counterfeit pork remains a pressing issue in Thailand despite government efforts. This illicit pork, smuggled into the country without inspection, poses health risks due to potential contaminants like growth hormones and chemicals. Salbutamol, a beta-agonist compound, is commonly used as a meat tenderizer and to intensify the color vibrancy of meat. However, residues of Salbutamol in meat and animal products pose potential health risks to consumers, including adverse effects such as vasodilation, tachycardia, tremors, headaches, nausea, vomiting, and even psychiatric symptoms. Recent studies indicate a significant increase in the detection of Salbutamol in pork samples compared to previous years.

Methods: The aim of this research is to study prevalence of Salbutamol residue in pork and to quantify the presence of Salbutamol in pork meat by systematically evaluating different meat cuts. A total of 100 meat samples were collected from diverse anatomical regions and purchased from 11 distinct locations in the Bangkok Metropolitan and around area. Our analysis aimed to disclose the extent of Salbutamol contamination within these meat specimens.

Results: Our results indicate a worrisome prevalence of Salbutamol residues in the meat samples, with approximately 74% (74 out of 100) testing positive for this compound. Significantly, the highest concentrations were detected in the Hock and Belly portions of the meat. In stark contrast, pork Loin displayed the lowest occurrence, with only 41% of the samples containing Salbutamol. This outcome strongly suggests that Salbutamol is more abundant in meat cuts that exhibit lower natural pigmentation, such as the Hock. It is evident that this practice of enhancing meat color serves as an enticing marketing strategy to lure customers into purchasing less 'red' meat cuts, thereby boosting overall meat sales.

Conclusion: In conclusion, our findings emphasize the pressing need for comprehensive regulations and awareness campaigns to address the unchecked use of Salbutamol in the meat industry, safeguarding the health and well-being of consumers while ensuring the integrity of the meat products available in the market. This research serves as an essential contribution to the ongoing discourse on the quality and safety of meat products in the food industry.

Keywords: contaminations, beta-agonists, side effects

Introduction

The problem of counterfeit pork continues to be a serious issue in Thailand, despite continuous efforts by the government to combat it [1]. The quantity of counterfeit pork sneaking into the country remains significant. Counterfeit pork refers to pork that is smuggled into Thailand without passing through customs checkpoints and without undergoing quality inspections. Consumption of counterfeit pork poses health risks, as it may contain contaminants such as growth hormones, insecticides, and residual chemicals. There is also a risk of contracting various diseases such as African Swine Fever [2]. Growth hormones refer to Beta-agonist chemicals such as Ractopamine, Salbutamol, and Clenbuterol, which are used to accelerate growth in animals.

Among the distinct various tools used in pork production all over the world, one of which is a category of compounds known as beta-agonists. These compounds are classified in the catecholamine group and serve its main purpose as a substance which promotes leaner muscle growth as well as a reduction of fat depositions in pork. Beta agonist is a main substance which works by acting on the beta-adrenergic receptors inside of the organism's body, which primarily mimics the effects of other compounds such as adrenaline by binding onto it. Beta agonist can be classified furthermore into 2 distinct group called Beta One (B-1) and Beta Two (B-2), Beta 1 comes into contact with the beta receptors which are already present in the heart and the nervous system, which Beta 2's receptor are found within the blood, digestive tracts or even the fats found in many cells. Some examples of the substance presented in Beta agonists are: Salbutamol, Clenbuterol, Bromobuterol, Cimbuterol, Mapenterol, Mabuterol, etc. As these agents are administered to the animals, the activation of these receptors trigger various physiological responses such as an increase in protein synthesis, reduction in Fat deposition, and more. An increase in protein synthesis could be observed from the compound, with it being one of the primary effects of Beta Agonists. Muscle fibre increases in size and number, which could lead to a development of lean muscle tissue. This phenomena occurs as the B-2 agents cause an exacerbation and reduction in plasma albumin, resulting in a higher muscle-to-fat ratio in the animal meat. On the other hand, significant reduction in fat deposition may also result from this compound by having the agents inhibit within the compound of fat which resides in the tissue of the muscle. Another surprising effect is accelerating the growth of swine. This happens because of the increase in the efficiency being displayed as the animals convert more of its mass into the lean muscle mass, causing an effect of the market weight reaching its potential faster or even reducing the resources required for the swine to grow. The use of beta-agonists in pork production could also offer many several advantages, one of which being an improvement in economic efficiency. The increase of lean muscle growth and reduction in fat could contribute more to efficient production in meat. Many farms and individuals could benefit more from the budget of resources and even the precious time. Another practical advantage may result in a better overall production. By adding such substances, many farms and establishments could yield a product which suits the customer preferences. The demand for lean meat is recently on the rise, with beta agonist being a huge assistance toward these preferences [3]. Notably, a concerning issue related to food contamination revolves around the use of beta-agonist chemicals or muscle-enhancing agents in animal feed, predominantly in pork and beef production, aimed at increasing muscle mass, reducing fat content in carcasses, and enhancing meat color. However, this practice carries substantial health risks, especially for expectant mothers and individuals with conditions like heart disease, high blood pressure, diabetes, or hyperthyroidism, as consuming contaminated food can lead to symptoms like back discomfort and neuroticism that may persist for days.

Salbutamol is a widely utilized bronchodilator for the treatment of respiratory conditions in both humans and animals, including veterinary medicine, effectively relaxing airway muscles to facilitate improved breathing. While generally safe when administered under veterinary supervision, Salbutamol can lead to side effects in animals, akin to its impact on humans, with variations in severity and likelihood contingent upon factors like species, dosage, and individual sensitivity. In animals, these side effects encompass symptoms such as tremors, excitability, elevated heart rate (tachycardia), increased blood pressure, muscle weakness, hypokalemia, and gastrointestinal disturbances, including vomiting or diarrhea. Furthermore, rare instances may involve allergic reactions, like hives, swelling, or breathing difficulties. Excessive exposure to Salbutamol may

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lead to adverse effects, such as cardiac muscle failure and heat stress due to heightened heat generation. For instance, swine may exhibit constant trembling when exposed to high levels of Salbutamol, and cardiac muscle failure can lead to fatalities in various animals [4].

In human medicine, Salbutamol is typically prescribed to manage respiratory conditions such as asthma, COPD, and chronic bronchitis. The NHS (2023) notes common side effects in humans, including transient sensations of shakiness, a temporary increase in heart rate, and headaches. However, more severe reactions, like muscle pain, weakness, cramps, or irregular heartbeats indicative of low potassium levels, can occur in certain individuals. Salbutamol may also rarely trigger serious allergic responses, such as anaphylaxis. At therapeutic doses, tachycardia, tremors, and hypokalemia can manifest, while overdose may lead to dry mouth, chest pain, nausea, seizures, or light-headedness [5]. Certain high-risk groups, including expectant mothers and individuals with heart disease, high blood pressure, diabetes, or hyperthyroidism, have reported prolonged discomfort and heightened anxiety following Salbutamol ingestion [6]. The prevalence and intensity of these effects are influenced by individual variables, dosage, and the method of administration. the use of beta-agonists, specifically salbutamol (SAL), in the feeding of farm animals and poultry is prohibited in several countries, including the Russian Federation, the EU, and China, as stated in the European Community, Council Directive 96/22/EC. Beta-agonists are a class of animal drugs designed to increase lean growth and feed efficiency in market beef cattle and market swine. They are approved feed additives and are deemed safe by the U.S. Food and Drug Administration (FDA). Beta-agonists have been approved for use in more than 24 countries, including the U.S, Canada, and Australia, with some countries having restrictions on specific types of beta-agonists. However, there have been cases of illegal use of beta-agonists in livestock breeding, which highlights the need for control measures. Despite the prohibition, there are still many reports about β-agonist residues in animal-derived foods across the continent

From past studies, it is evident that the detection of Salbutamol growth enhancer in pork samples has significantly increased compared to before and during the counterfeit pork situation in 2021. For instance, Chakmongkol and colleagues [7] found Salbutamol in 108 out of 1,527 pork samples, accounting for 7.07%.Similarly, Piwkham and colleagues [8] discovered positive results in 99 out of 3,135 pork samples, making up 2.99%. In a study by Aroonpanlop, and colleagues [9], 99 out of 140 pork samples tested positive for Salbutamol, representing 71.22%. Additionally, Wattanasawang, and colleagues [10] found 7 out of 10 fresh pork samples from grill pork shops in Samut Prakan province tested positive, accounting for 70.00%. Ravadchai, and colleagues which reported that 60% of pork samples collected from the fresh market area of Nakhon Ratchasima Municipality, Mueang, Nakhon Ratchasima Province, contained residual Salbutamol [11].

The aim of this research is to study prevalence of Salbutamol residue in pork and to quantify the presence of Salbutamol in pork meat by systematically evaluating different meat cuts. This experiment will raise awareness about salbutamol residues may be founded in the pork we consume and it potential health risk it may cause.

Material and Methods

A cross-sectional used to survey the present study to experiment with Salbutamol contamination in accordance with food sanitation guidelines and any notifications from the Ministry of Public Health. The investigation was conducted in several of Bangkok's fresh marketplaces. Data was gathered during October 2023.

Sample size calculation

The sample size was calculated using the formula based on the mean percentage incidence detected in previous studies involving Salbutamol contamination in meat product by Guo and colleagues and Xu and colleagues [12,13] as below:

$$N = \frac{Z^2_{\alpha/2}\, P(1-P)}{e^2}$$

Where

n = sample size; P = Mean percent incidence detected; Z = confidence level (in this research, 95% confidence level, Z= 1.96); and e = the proportion of error allowed (5%). The sample size required was 50 samples. However, in the present study we used a total of 100 food samples for increasing sensitivity.

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Sample preparation and Screening for Salbutamol

The chosen pork sample is crushed into small sizes prior to the experiment. Each distinct sample (n = 100). The Salbutamol detection kit was used to determine residue Salbutamol levels. In brief, a pork sample is carefully transferred into a glass test tube. The test tube is then filled with 3 ml distilled water. Subsequently, the sample is placed in boiling water and boiled for a full 20 mins before being allowed to cool. Once it has cooled, the sample is filtered by placing filter paper onto a filter cup. The filtered sample is then drawn into a 1 ml test tube. Additionally, specific volumes of SBT-1, SBT-2, and SBT-3 solutions are drawn into separate test bottles, with 1 ml of SBT-1 solution, 1.5 ml of SBT-2 solution, and 0.5 ml of SBT-3 solution added to their respective test tubes. To complete the testing process, the test bottles containing the various solutions are immersed in warm water, with temperatures ranging from 60 to 70 degrees Celsius, for a duration of one hour. Following this immersion, the results were subject to interpretation. In the interpretation of the results, the presence of a reddish-brown hue was indicative of the presence of Salbutamol in the tested sample.

Interpretation

Presence of Salbutamol residue can be determined by observing for the color change in the test tube provided by the Salbutamol residue detection kit. If the test tube remains colourless, Salbutamol residue is not present in the sample. Whereas, if the test tube turns partially or completely reddish-brown hue, the sample contains Salbutamol residue. It's noteworthy that the minimum detectable concentration for Salbutamol in this study was 10 ppb.

Data Analysis

Descriptive statistics, such as frequency and percentage, were used to analyse the data.

Results

In this investigation, a total of 100 individual pork products are tested and sampled for Salbutamol residue. The samples are collected and purchased from 11 different locations in Bangkok's Metropolitan Region to ensure a well rounded sampling area. The samples can be categorised into 6 different sample groups which are, pork collars, pork loin, pork neck, belly, ribs and hocks. During the sampling, the number of samples for each category are recorded in detail as well as the physical qualities such as colour, composition, and shape, amount of fats, meat and bone which will be used to determine the method of Salbutamol sampling used on each pork product. Overall, the red meat used in this study mostly contains red meat and very little fats.

Table 1: Physical Qualities and Location of Purchase for the 100 Different Pork Products Tested for Salbutamol Residue

Group Number	Sample Name	Number of Samples	Physical Qualities	Location of Purchase
1	Pork Collar	7	It is a cut with a balanced mix of lean meat and marbling. The meat was redder than usual.	Lat Phrao District Chatuchak District Phaya Thai District Ratchathewi District

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2	Pork Loin	17	It is a boneless cut of meat and has a relatively low fat content.The meat was redder than usual.	Lad Phrao District Chatuchak District Phahonyothin District Klongtoey District Praya Thai District Pathumwan District Minburi District Ratchathewi District
3	Pork Neck	13	It consists of lean meat with minimal fat marbling.	Klongtoey District Nakhon Pathom Province Phra Khanong District
4	Belly	19	It is an alternating layer of meat and a small amount of fat.The meat was redder than usual.	Khlong Toei District Phaya Thai District Ratchathewi District Chatuchak District Thon Buri District Pathum Wan District
5	Ribs	8	It consists of both meat and bones. The meat was redder than usual.	Khlong Toei District Ratchathewi District Pathum Wan District
6	Hock	36	It contains a combination of meat, skin, and connective tissue. There is scant fat content.The meat was redder than usual.	Khlong Toei District Phaya Thai District Ratchathewi District Chatuchak District Thon Buri District Pathum Wan District Phra Khanong District Nakhon Pathom Province

According to Table 2, Belly has the highest number of Salbutamol Residue contaminated samples. Out of 19 Belly samples, 18 samples yielded a positive result from the Salbutamol Residue test kit, which is 94.74% of the total Belly samples that is 18.00% of the total product. Out of 8 Ribs samples tested, 7 samples are Salbutamol positive which is 87.50% of the total ribs sample that is 7% of the total product. Moreover, 4 out of 7 samples of pork collar tested are contaminated with Salbutamol, which is 57.14% of the pork collar samples.10 out of 13 of the pork neck was tested positive for Sabultamol which is 76.92% of the total pork neck. Hocks have the most samples and out of 36, 28 were tested positive for Sabultamol which is 77.78% of the total hocks. On the contrary,

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pork loin are the least contaminated products with only 7 contaminated samples out of 17;41.17% of the pork loin or only 7.00% of the total. In summary, there were 100 samples tested for Sabultamol using the Salbutamol residue detection kit. 74 out of 100 samples or 74.00% of the samples are Sabultamol contaminated.

Table 2: Analysis result of the amount and percentage of Salbutamol residue found in the 100 different food samples.

Group Number	Sample Name	Number of Samples	Salbutamol Residue Testing		Percentage in finding Salbutamol within group (Percentage in finding Salbutamol in total)
			Found	Not Found	
1	Pork Collar	7	4	3	4 out of 7 57.14 (4)
2	Pork Loin	17	7	10	7 out of 17 41.17 (7)
3	Pork Neck	13	10	3	10 out of 13 76.92 (10)
4	Belly	19	18	1	18 out of 19 94.74 (18)
5	Ribs	8	7	1	7 out of 8 87.50 (7)
6	Hock	36	28	8	28 out of 36 77.78 (28)
Total		100	74	26	

Discussion

Our findings revealed a high prevalence of Salbutamol residues in the meat samples, with approximately 74% (74 out of 100) testing positive for this compound. The highest concentrations were found in the Hock and Belly sections of the meat, while the Pork Loin showed the lowest incidence, with only 41% of samples containing Salbutamol. This suggests that Salbutamol is more prevalent in meat cuts with reduced natural pigmentation, such as the Hock.

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This study results are consistent with previous studies. For example, Ravadchai and colleagues [11] reported that 60% of pork samples from the fresh market area of Nakhon Ratchasima Municipality contained residual Salbutamol. Similarly, Wattanasawang and colleagues [10] found 70% positivity in fresh pork samples from grill pork shops in Samut Prakan province, while Aroonpanlop and colleagues [9] reported a positivity rate of 71.22% in pork samples.

These rates are higher compared to studies conducted before the 2021, when the counterfeit pork situation was first reported, such as those by Chakmongkol and colleagues [7] and Piwkham and colleagues [8], indicating an increase in Salbutamol prevalence possibly due to the influx of counterfeit pork. The prevalence of Salbutamol residues in pork has increased significantly from before 2021 to the period of 2021-2023, likely influenced by the ongoing counterfeit pork situation in Thailand. Counterfeit pork imports remain a concern, highlighting the need for stricter enforcement measures to protect consumers' health.

Hwang [14] explains that the variance in contamination rates across different pork cuts can be ascribed to physiological disparities in animals and the distribution of Salbutamol within their bodies. While Salbutamol is commonly used as a bronchodilator for respiratory conditions in humans, its illicit use in livestock production aims to enhance lean muscle growth and reduce fat deposition.

The distribution of Salbutamol in pork cuts is influenced by their composition. Cuts like belly and hocks, with higher fat content, may exhibit higher concentrations of the drug due to its affinity for fatty tissues. Conversely, lean cuts like pork loin show lower contamination rates as the drug is less likely to accumulate in lean muscle tissue. To reduce the risk of contamination, recommendations can be made for both pork suppliers and consumers. For suppliers, it's crucial for swine farmers to keep detailed medication records, use authorized medications under veterinary supervision, and enforce strict biosecurity measures to prevent external contamination. Regular monitoring and testing of meat samples for Salbutamol residues are essential, along with providing training to farm workers on proper medication handling and following withdrawal periods [15,16]. For consumers, to avoid consuming pork with Salbutamol residues, it's advisable to purchase pork from reputable sources. Products with quality assurance labels, such as "hygiene pork" or "organic pork," provide assurance of product integrity. Additionally, consumers should inspect meat products for any signs of contamination and source pork from reliable retailers or distributors.

In summarize, the widespread presence of Salbutamol in pork meat emphasizes the need for comprehensive regulations and awareness campaigns to address the unchecked use of this compound in the meat industry. Such measures are essential to safeguard the health and well-being of consumers and ensure the integrity of meat products available in the market. This research serves as a critical contribution to the ongoing discourse on the quality and safety of meat products in the food industry. Future research should focus on developing more accurate and reliable detection methods for Salbutamol residues in meat and investigating the presence of Salbutamol in other types of meat besides pork. Additionally, it is crucial to educate consumers about the potential health risks associated with Salbutamol residues in meat and to promote the consumption of meat products that are free from harmful chemicals.

Conclusion

In the experiment 100 samples of pork were used. Salbutamol residues were found to contain in 74 samples which was 74% of the total samples. The main attribution is obviously from pork counterfeit that have been an unsolved problem so far. The study uses a total of 6 parts consisting of pork collar, pork loin, pork neck, belly, ribs and hocks. From 74 samples that were found to contained Salbutamol residue, 4 were found in pork collar, 7 of pork loin, 10 of pork neck, 18 of the belly, 7 of ribs and 28 of hocks were tested positive for Salbutamol. These findings suggest a significant prevalence of Salbutamol contamination in the tested pork products, with belly and hocks showing the highest contamination rates, while pork loin had the lowest contamination rate. The results of this study can raise concerns about the use of Salbutamol in pork production, as it is typically used as a bronchodilator in the treatment of respiratory conditions in humans and may not be approved for use in livestock. Further research and regulatory measures may be necessary to address this issue and ensure food safety.

Suggestion

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Individuals at risk of illness due to Salbutamol such as heart disease, high blood pressure, diabetes, or hyperthyroidism may want to apply the results gained from this research paper as an asset for a better decision of meat selection. Moreover, to avoid Salbutamol residues and other Beta agonists in pork products, consumers can buy pork from trusted sources such as branded products which are produced by standard swine farms.

Relevant agencies should conduct surveillance for an excessive amount of Salbutamol in various meats yearly, to guarantee that the customers who indulged in these ingredients won't be subject to the side effects of the substance.

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