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Analysis of the current situation of resource utilization of corn straw

Yadong，Guo
（School of Agricultural Engineering and Food Science,Shandong University of Technology, Zibo,255000,China）

Abstract:
With the rapid development of Chinese agricultural modernization, the amount of agricultural waste is also growing. And corn straw, as a typical type of agricultural waste, has the characteristics of high yield and high recovery value. This paper introduces the comprehensive utilization of corn straw from five aspects: corn straw burning, feed, fertilizer, bioreactor and energy, and analyzes the advantages and disadvantages of each utilization pathway to provide a reference basis for the resource utilization of corn straw.
Keywords: *agricultural waste; corn straw; resource utilization*

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I. Introduction

The rapid development of agricultural modernisation has greatly increased agricultural productivity, but it has also brought about some drawbacks. The increase in agricultural productivity represents an increase in agricultural waste (livestock manure, straw, mulch and pesticide plastic packaging, etc.). Irrational disposal of agricultural waste can lead to serious environmental pollution and waste of resources. The recycling of the hydrocarbon resources contained in the waste through appropriate technology is not only an effective solution to the problem of harmless, reduced and resourceful treatment of agricultural waste, but also an important way to achieve Chinese "double carbon" strategic goal. As a typical representative of agricultural waste - corn straw, people have been treating straw as rubbish, usually by burning or burying, which not only covers up the potential value of corn straw, but also brings pollution to the environment, affecting human health and sustainable development. The development of science and technology has brought hope for the resourceful recycling of corn straw, and people are beginning to realise the importance of corn straw, and through various ways to explore the value of corn straw, to achieve efficient recycling of corn straw.

II. Direct burning

Straw is characterised by high looseness, high volatile content and high water content. Burning using traditional cookers in rural areas can cause problems such as inadequate combustion and low combustion efficiency due to the large concentration of volatile fraction precipitated. On the one hand, the straw needs to be pre-treated and baled and pressed into a fast to facilitate controlled combustion. On the other hand, it is necessary to develop combustion devices suitable for straw as a fuel, and they need to be in line with the current situation in our countryside, only then will straw burning have more potential for development and be conducive to protecting the ecological environment and promoting rural development.

Foreign students have been studying biomass combustion devices for a long time, and have already developed mature combustion devices to industrialise biomass heating. 1950s, Japan and the USA developed special combustion equipment for biomass fuels, followed by other Western countries. It was not until the beginning of the 21st century that China developed a hot water boiler combustion technology adapted to direct straw combustion, which was designed for the biological characteristics of straw itself[1] . This technology set a precedent for the development of straw-fuelled combustion equipment in China. At present, China has three direct combustion technologies. Oxygen-poor inverse layer combustion technology has the advantages of high combustion efficiency, low fuel consumption per unit of time and a wide range of fuel sources, as well as saving material, time and labour, which is more suitable for the majority of farmers. Semi-gasification inverse combustion technology and countercurrent combustion theory secondary combustion technology is suitable for application in concentrated mass combustion[2] .

Although various combustion devices have improved the utilisation rate of straw, they still do not accurately control straw combustion, and research into control devices needs to be strengthened. Research on the combustion characteristics of straw fuel is not perfect, the combustion exhaust gas contains NO and other harmful gases, the basic theory of straw fuel research needs to be strengthened, the exhaust gas treatment device to further improve.

III. Corn straw feed

Corn straw has long been one of the raw materials used to make roughage. Rich in cellulose, hemicellulose and lignin, and low in protein and fat, corn straw can be fed directly to livestock and preserved in silage. Feeding corn straw can protect the ecological environment, reduce the cost of animal husbandry, improve the utilisation rate of straw, solve the problem of food competition between humans and animals, and achieve the unity of ecological and economic benefits. However, the high crude fibre content and the low protein content and poor palatability of corn straw are the main factors that limit the ability of corn straw to become feed. Therefore, reducing the crude fibre content and improving the nutrients and palatability are important ways to achieve feed ability of corn straw. Currently, corn straw can be pretreated to increase the protein content and improve the palatability of the straw, with the following three more mature pretreatment methods.

(1) Biological silage: Silage is generally made from tall, lush corn stalks, which are rolled and sealed in the cellar before they are ripe, and transformed into a palatable, nutritious and high quality feed by anaerobic fermentation with lactic acid bacteria.[3] The straw is transformed into a palatable, nutritious and high quality feed. Silage effectively preserves the green straw so that people can still feed their livestock with green feed in winter. Feed stored using the silage method effectively degrades crude fibre, significantly increasing the protein content and promoting livestock feeding and weight gain. The application of silage technology not only adjusts the structure of corn cultivation by changing the grain to feed, but also improves the utilisation rate of corn straw[4] This not only maintains the ecological environment, but also improves the utilisation rate of corn straw. This not only maintains the ecological environment, but also ensures the sustainable development of the livestock industry.

(2) Chemical processing: Chemical processing of feed is generally referred to as ammoniation and is the most practical method of treatment.[6] . Corn straw is mixed with nitrogen fertiliser and fermented to destroy the biomass structure and separate cellulose and lignin for digestion and absorption by livestock. The ammoniation method takes less time and also improves the digestibility of crude fibre, increases crude protein content, reduces nutrient losses and contains a large number of amine salts, which significantly improves the palatability of the feed.

(3) Puffing: Puffing technology is a physical and biochemical compound processing feed technology[6] . The use of physical friction, strong extrusion of materials, resulting in high temperature and pressure, materials from powder to paste, and then through the spout spray. Under sudden changes in temperature and pressure, the corn straw puffs and erupts, prompting the complex structure of the biomass to disintegrate. The straw is then fermented, releasing the nutrients in the straw and further improving its nutritional content and utilisation value. Furthermore, the puffing technology also has a high temperature insecticidal and sterilising effect, reducing the incidence of livestock disease.

At present, China's straw feed technology has gradually matured, can provide a large number of high-quality feed for animal husbandry. However, due to the high cost of straw transportation and seasonal variations in production, it is difficult to industrialise straw feed. On the one hand, the livestock industry has promoted straw fodder, on the other hand, straw fodder is also constrained by the scale of breeding.

IV. Straw returned to the field

The return of straw to the soil, which in fact means returning the organic and mineral elements in the straw to the soil, is a measure that is valued worldwide as a way of increasing yields in cultivated soils and reducing the problem of environmental pollution caused by straw burning. Although chemical fertilisers can have the effect of increasing yields and incomes, their unreasonable use can lead to severe soil caking. Straw can also increase soil organic matter, improve soil, reduce harmful soil substances, improve microbial activity and promote crop root development. However, improper straw return methods can cause problems such as increased soil pathogens and lack of seedlings. Therefore, the only way to achieve the desired effect is to adopt a scientific way of returning straw to the field. According to the process of returning straw to the field, it can be roughly divided into direct and indirect return to the field.[5] The process can be divided into direct and indirect.

Direct return to the field

Direct return is the direct treatment of straw to the field, including tillage and mulching. Turning is the process of turning the straw into the soil after the crop has been harvested. However, this method generally requires shredding before turning into the soil. Mulching is the process of covering the soil surface with straw.[7] This method reduces the evaporation of soil water and reduces the amount of water in the soil. This method reduces the evaporation of soil moisture and facilitates the decomposition of organic matter. The main purpose of direct mulching is to improve soil minerals and organic matter through subsoil decomposition, to relieve soil consolidation, to increase soil permeability and fertility, and to increase yields and yields.

Indirect return to the field

Indirect return to the field involves microbial decomposition to make organic fertiliser before sowing it back into the field. It includes composting, biochemical decomposition, fermentation and overstuffing.[8] The organic fertiliser can effectively reduce soil caking. Organic fertilisers can effectively reduce soil caking and also increase soil pore space and organic matter content. The use of organic fertilisers not only improves soil fertility, but also reduces farmers' reliance on chemical fertilisers and is an environmentally friendly soil fertiliser. Biochar-based fertilisers have been a hot topic of research in recent years. Biochar is produced by high temperature cracking of biomass under anaerobic conditions. Biochar-based fertiliser applied to the field is considered a carbon sequestration and emission reduction initiative that can improve the soil's ability to retain water and fertiliser.

Returning straw to the field is a way of seeing straw as a potential fertiliser that not only cultivates soil fertility but also fixes carbon in the soil, reducing carbon emissions from another perspective and achieving a unified ecological and economic benefit. Straw returns to the field have disadvantages such as long cycles and slow results, and need to continue to improve straw fertilisation.

V. Straw bioreactors

Straw bioreactor technology is a new concept in organic cultivation that increases yield, quality and efficiency in agriculture, and is fundamentally different from traditional agricultural techniques in that it gets rid of the dependence on chemical fertilisers. The main theoretical basis of the straw bioreactor is the photosynthesis of plants, the theory of plant starvation, the theory of active and passive absorption of leaves and the theory of recyclable reuse of straw mineral elements. This is its innovative concept and the biggest difference from traditional agriculture. Corn straw reactor technology is mainly used in greenhouses. The corn straw is buried in trenches in the greenhouse and, under the action of micro-organisms and purifying agents etc., is transformed in a targeted manner into CO_2, heat, disease-resistant spores, enzymes and organic fertiliser needed for plant growth.[9] The greenhouses are also a source of organic fertiliser. The increased concentration of CO_2 in the greenhouse boosts the photosynthetic efficiency of the crop; the increased heat reduces the cost of insulation; the disease-resistant spores improve the crop's resistance to pests and reduce the use of pesticides; enzymes turn ineffective fertilisers into effective ones and harmful substances into beneficial ones; and organic fertilisers improve the soil. Straw bioreactor technology replaces chemical fertilisers with straw and pesticides with plant vaccines, which can protect the ecological environment and achieve increased yield, quality and pollution-free agricultural products.

Only in relatively confined spaces can straw bioreactor technology retain products such as CO_2, heat, disease-resistant spores and enzymes, and re-activate these products into crop growth, making maximum use of the energy produced by straw fermentation, making it an almost perfect technology for agricultural production. However, it can only be implemented in relatively confined spaces, such as greenhouses, which severely limits the application of straw bioreactor technology.

VI. Corn straw energy

Anaerobic fermentation

Anaerobic fermentation is the process by which organic matter is fermented and decomposed by microorganisms under anaerobic conditions and converted into biogas.[10] Biogas consists mainly of gases such as methane and CO_2, is an efficient, clean and convenient source of energy. Anaerobic fermentation technology not only recycles and reuses corn straw, but also reduces pollution, alleviates the energy crisis and brings comfort and convenience to human life. However, temperature and fermentation broth concentration have a huge impact on anaerobic fermentation technology, and the most economical temperature condition is 35°C. During the cold winter season, fermentation can be difficult and take a long time. Therefore, it is necessary to set up insulation around the digester to pre-treat the corn straw, destroy its structure, increase the contact area between microorganisms and straw, speed up the decomposition rate and improve the efficiency of biogas production.

Anaerobic fermentation technology is a relatively mature straw resource utilisation technology. However, it cannot precisely control the fermentation process and has to rely on the environment to influence it, which greatly restricts its industrialisation. Therefore, further improvement of fermentation facilities and strengthening of theoretical research on anaerobic fermentation are needed.

Thermochemical conversion

Corn straw uses photosynthesis to convert solar energy into chemical energy that is stored in the straw, making it a carbon-containing renewable energy source. Biomass thermochemical conversion technology is a technology that cracks biomass under heated conditions to produce substances such as gas and bio-oil, including gasification, liquefaction and pyrolysis. The following three aspects of corn straw gasification, liquefaction and pyrolysis are described.

(1) Straw gasification

Biomass gasification is a thermochemical reaction that converts biomass into combustible gases such as CO, H_2 and methane under high temperature conditions using biomass as a raw material and air or water vapour as a gasification agent. In principle, both gasification and combustion are reactions between biomass and oxygen. The major difference is the adequacy of oxygen. Gasification is a reaction with limited oxygen, the biomass is not fully oxidised and the carrier of biomass energy is converted from a solid to a gaseous state. Corn straw has a high volatile fraction and is more suitable as a raw material for gasification technology. The combustible gas produced by the cracking of corn straw can be used after treatment for home heating and power generation in farmers' homes[11] The gasification technology is a simple, easy to use process. The gasification technology is promising because of its simplicity, low cost and wide range of raw material sources.

(2) Direct liquefaction of straw

Direct biomass liquefaction is a technology that uses water or organic matter as a solvent, adds biomass and a catalyst, and heats and pressurises the biomass under oxygen-free conditions to crack the biomass and thereby obtain liquid oil. Supercritical liquefaction of biomass using water as supercritical is known as hydrothermal liquefaction. Hydrothermal liquefaction does not require consideration of the water content of the biomass and is applicable to a wider range of biomass feedstocks. The lignin and cellulose in corn straw can be hydrothermally liquefied to produce higher quality liquid fuels. Corn straw liquid fuels are green, clean and renewable and can replace fossil fuels in some areas and can mitigate greenhouse gas emissions.

(3) Straw pyrolysis

Straw pyrolysis refers to the process of using heat to break chemical bonds and produce low molecular weight compounds under anaerobic or anoxic conditions. The main products of pyrolysis are biochar, bio-oil and biogas. The yield and composition of pyrolysis products vary greatly depending on the conditions of pyrolysis. Bio-oil has disadvantages such as high oxygen content, low calorific value, poor stability and difficulty in separation and purification, which are bottlenecks to the development of pyrolysis.[12] The development of pyrolysis has been limited by the addition of catalysts. The products are targeted and regulated by adding catalysts. or co-catalytic pyrolysis of straw with hydrogen supply additives to prepare high quality chemicals[13] .

Thermochemical conversion is an important part of the energy of corn straw, with a wide range of conversion products. It is also possible to separate the cellulose, hemicellulose and lignin from the straw and then prepare high value organic matter by thermochemical conversion. At present, the thermochemical conversion method is not yet complete and the converted products still need to be separated before they can be used.

VII. Conclusion

In order to achieve sustainable agricultural development, resource recycling and a circular economy in agriculture, agricultural use should be the main focus when dealing with corn straw, the preparation of corn straw fertilizer and feed should come first. Moreover, straw feed can be returned to the field after passing through the belly. Straw fertiliser and feed minimise 'carbon emissions' and store carbon in solid form in the soil. Bioreactor technology is an innovative agri-culture technology that uses almost everything that is produced by the decomposition of straw, making it truly recyclable. Anaerobic fermentation and thermochemical conversion convert straw into high-quality energy, utilising biomass as a renewable energy source.

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