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Research and Prospect of Food Fuels Issues

Jiayao Zhou [1,2], Zheru Wang [2], Danyan Ding [2], Chuchu Liu [2]
1 Cuixi Academy of Biotechnology, Zhuji, 311800, China
2 Institute of Life Science, Jiyang College of Zhejiang A&F University, Zhuji, 311800, China
Corresponding author email: zhoujiayao@molplantbreed.org
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Abstract The development of biofuels is not only related to energy and environment, but also closely related to the global wealth gap and food security. In recent years, with the rapid development of the global economy and the increasing population, the demand for energy is also increasing. At the same time, due to the negative impact of the use of fossil fuels on the environment, more and more people are beginning to consider using biofuels as substitutes. As a kind of biofuel, grain fuel has attracted more and more attention. Food VS Fuel has been a dilemma over the years. But when biofuels are used correctly, society cannot ignore the positive effects it brings, such as reducing greenhouse gas emissions, resulting in environmental and social benefits. Of course, society cannot accept the negative effects of biofuels, such as wasting more fossil energy for refining biofuels, and at the same time, due to grain shortages, world grain prices continue to rise. Due to the exhaustion of non-renewable energy and the requirements of environmental protection, biofuels have gradually become the new favorite of alternative energy sources. As an important source of biofuel, grain has also attracted people's extensive attention. This review will comment on and look forward to the problem of food fuel, including crops that can be used as fuel, the existing problems of food fuel, the related background and development status of biofuels, the impact of food fuel on grain prices, and the summary and prospect.
Keywords Grain crops; Biofuels; Fuel; Exist problem; Future prospects

Food fuels belongs to biofuels. Biofuels refer to bio-based products, biofuels and bioenergy produced through industrial processing and conversion using renewable or recyclable organic materials, including crops, agricultural products and other plants and their residues, livestock and poultry manure, organic wastes, etc. At present, biodiesel and fuel ethanol are the two main types of biofuel products, which are closely related to the food market. Some crops, such as corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), sugar beet (*Betavulgaris* L.), cassava (*Manihot esculenta*), rape (*Brassica napus* L.) and sugarcane (*Saccharum officinarum*), can be used to make biofuels. Biofuels play an outstanding role in ensuring national oil security, alleviating the crisis of excessive dependence on oil imports, and effectively reducing pollutant emissions from motor vehicles. At present, biofuels mainly include bioethanol and biodiesel. In the past decades, food fuel has gradually become a new type of energy because of the dependence on fossil energy and the concern about environmental pollution. At present, food fuels have become an important part of global energy consumption. Among them, the United States, Brazil, the European Union and other countries and regions are in a leading position in the production and utilization of food fuels. In China, the production and utilization of food fuels is also gradually developing, but overall it is still in its infancy.

In the case of increasing energy and ecological pressure, the development of biofuel industry is a relatively effective solution. Biofuels emerged in the 1970s and achieved rapid development in this century.. In the United States, about 40% of the corn is used to produce biofuels each year, and the goal is to replace more than 75% of oil imports from the Middle East with biofuels by 2025. The predicted data of the “Technology Roadmaps-Biofuels for Transport” from the International Energy Agency indicates that the proportion of biofuels in transportation fuels will increase from 2% to 27% by 2050. Food security is one of the most important human needs, so it is of significant practical significance to discuss the mechanism and results of biofuel industry's impact on food security.

However, the development of food fuels also faces some problems. First, the production of food fuels requires large amounts of crops and land resources, which may have implications for food security and sustainable agricultural development. Secondly, the production and utilization of food fuels will also bring some environmental problems, such as land occupation, water resources consumption and biodiversity destruction. In order to solve these problems, this review will start from the production of food fuels, related background, development status and other aspects of in-depth discussion, and put forward the corresponding suggestions and prospects. Specifically, we will focus on the following aspects: Firstly, how to improve the production efficiency and resource utilization efficiency of food fuel, and reduce the consumption of agricultural resources; Secondly, how to strengthen environmental supervision over the production and utilization of food fuel, and protect the ecological environment; The third is how to formulate more scientific and reasonable food fuel policies to promote sustainable development. Through the research and analysis of this review, we hope to provide some useful ideas and suggestions for the development of food fuel, and also call on all sectors of society to pay attention to and participate in the sustainable development of food fuels, and jointly promote the green transformation of the energy field.

1 The Relationship between Grain Crops and Fuels

China has made significant progress in key technologies of biomass utilization, such as lignocellulosic hydrolysis, microbial utilization, bioreactor and product purification technology. If 5% of the crop residues, 40% of the manure of livestock and poultry, 30% of the forestry wastes, and about 5.5×10^6 hm^2 of marginal land can be used to grow energy plants, the energy produced can be equivalent to 5×10^7 t of oil, equal to 29% of the total fossil oil production in 2004 and 35% of the net import. In southwest China, wood oil such as Mafengshu (*Jatropha curcas* L.) has developed rapidly, and the oil content of its seeds has reached 50%; China is one of the major corn producers in the world, with an annual planting area of about 2×10^7 hm^2, and about 4×10^6~6×10^6 t of corn left over every year, excluding the needs for food, feed and brewing. In addition, the varieties of hybrid rape in China are at the leading level in the world, and the planting area and total output of rape rank first in the world, with abundant rapeseed resources and sufficient raw materials for developing biodiesel. At the same time, China is also the largest cotton producer in the world, with an annual output of more than 1.3×10^7 t of cottonseed, which can also be used to produce biodiesel.

It can be seen that the raw material sources of biomass fuel are very wide. As long as the rational development of bioenergy, it will not pose a threat to food security, but can guarantee food security to a certain extent. The use of biomass can not only make China's limited arable land meet the needs of food and feed, but also replace the fermentation industry to produce amino acids, antibiotics and other products, equivalent to a 5% increase in food production. In order to develop biomass resources, China has launched an energy crop cultivation program, which is planned to divide energy crops into four categories: 1. Annual or perennial crops for alcohol production, such as corn, sugarcane, sorgo, sweet potato, cassava, etc. 2. Plants for the production of fuel oil (such as biodiesel, hydrocarbons), such as rape, Lyuyushu (*Euphorbia tirucalli* L.), Huanglianmu (*Pistacia chinensis* Bunge), etc.; 3. Plants used for direct combustion; 4. Algae or other plants for anaerobic fermentation. Some financial support will be provided for planned energy plants (Figure 1).

Figure 1 An ethanol fuel plant under construction, Butler County, Iowa

1.1 Food fuels and corn

In China, food mainly includes grains, beans and tubers. China's food production is dominated by grains, including wheat, rice and corn as well as sorghum and millet. Of the three main grains, wheat and rice are commonly referred to as the rations, while corn (*Zea mays* L.) is only partially eaten, mostly used as feed grain and industrial grain. In 2001, corn accounted for 59% of the domestic ethanol raw materials, but by 2005 it had increased to 79%. The proportion of corn ethanol grains used far exceeds that of the United States and Brazil in 2005/2006, with the United States using only 17.6% of the country's corn production for bioethanol. By the end of 2014, China had approved 11 fuel ethanol projects. A total of 17 280 000 t of fuel ethanol were produced and consumed, and about 57 680 000 t of corn, wheat, rice and cassava were consumed, among which about 12 110 000 million t of corn, rice and wheat that could not be eaten by humans and livestock were converted. At present, China's annual fuel ethanol production capacity has reached about 2.4×10^6 t, ranking third in the world after the United States and Brazil in terms of annual production and consumption. At present, the development of fuel ethanol to consume "problem food" has become one of the most economical and feasible ways. It is estimated that if the use of fuel ethanol is promoted nationwide, the capacity of fuel ethanol will need to be increased by more than 8 million t/year, and about 2.5×10^7 t/year will be converted into fuel ethanol using corn as fuel (Figure 2).

Figure 2 Food fuel and corn

1.2 Food fuels and cassava

The most cost-effective source of ethanol fuel is cassava (*Manihot esculenta*), which produces an average of 1 t of alcohol for every 27 t of cassava. Many energy plants can be grown on marginal land where natural conditions are poor and it is difficult to grow root food, but where plants can grow. According to statistics, China now has 1×10^7 hm^2 of saline-alkali land, 5×10^7 hm^2 of wasteland and 1.8×10^7 hm^2 of low-quality land, which is a little more than the current cultivated land and has a vast potential for cultivation. Therefore, as long as such energy plants are vigorously developed and cultivated on a scale and in a targeted way, the development of the biofuel industry will not affect food security, but also make marginal land without economic value become an energy base.

Cassava, grown in the south, is suitable for planting in Karst areas with shallow soil layers and difficult to maintain rainfall, so it does not compete with food crops for land. China currently produces about 8×10^6 t of cassava a year, 60% of which comes from Guangxi, and imports about 3×10^6 t a year from Southeast Asia. There is great potential to produce fuel ethanol from cassava as long as companies establish a stable feedstock base (Figure 3).

1.3 Food fuels and sorgo

Sorgo (*Sorghum vulgare* L.) has the highest photosynthetic efficiency among all plants, and is resistant to drought, waterlogging and saline-alkali. It can be planted in the land with PH value of 5~8.5, and the straw height can reach more than 3 m. From the mouth of the Yellow River in Shandong province to the Bohai Bay all the way to Dalian, most of the coastal beaches are suitable for growing sorgo, which cannot grow food because of the high salinity. The sugar content of sorgo straw is 18% to 20%, even higher than sugarcane, and the sugar can be fermented into alcohol. Sorgo stalks yield is an average of 48 t per 667 m^2 and about 1 t of alcohol per 2 667 m^2. Using 10% of the saline-alkali land to grow sorgo can satisfy the current fuel ethanol production, and there is no problem of competing with the people for food and land (Figure 4).

Figure 3 Food fuel and cassava

Figure 4 Food fuel and sorgo

1.4 Food fuels and straw crops

A new technology of making cellulosic ethanol from straw has attracted more and more attention. According to statistics, about 7×10^8 t of straw are produced in China every year. In rural areas, these stalks are usually burned in the fields, which not only wastes energy but also causes air pollution. If 1×10^8 t of the 7×10^8 t of straw were used to make fuel ethanol, at 10 percent conversion efficiency, 1×10^7 t could be produced annually, which would be several times the current total national fuel ethanol production (Figure 5).

Figure 5 Food fuel and straw crop

1.5 Food fuel and rapeseed oil

As biodiesel, rapeseed oil has its unique advantages, rapeseed oil-low erucic acid is an ideal raw material for biodiesel because its fatty acid carbon chain composition is similar to the carbon number of diesel molecules.

China has about 9×10^6 hm^2 of vacant field in winter and summer every year. If it is used to grow rape, it will not affect the production of rice and other main grain crops. Moreover, rape is a crop of land and cultivation, which has the function of fertilizing the field and resisting disease, and can increase the yield of rice and other succeeding crops by about 10%.

As an ideal raw material for biodiesel, rape has the advantages of wide application range and great development potential. It is an energy oil crop with the greatest development potential in China and has important strategic significance.China ranks first in the world in terms of planting area and total output of rape, and its hybrid rape varieties lead the world, with abundant rapeseed resources. And it is suitable for growth at the Yangtze River basin, Huanghuai region, Northwest and Northeast regions. Only the Yangtze River basin and Huanghuai region have more than 2×10^7 hm^2 of rice fields suitable for rape cultivation in the winter. At present, the total production of rapeseed in China is about 1.3×10^7,t with an average oil content of 37.5% and an average annual consumption of 1.35×10^7 t, with a gap of 5×10^5 t. A portion of rapeseed is imported annually, but a small amount of rapeseed oil is also exported. In 2005, China exported 30 600 t of rapeseed oil. Among them, 12 200 t were exported to Germany and 9 300 t to the Netherlands. With the development of biodiesel, the demand for rapeseed oil increases and the price rises. The production potential of rape in China will be gradually brought into play.

2 Biofuels and Food Security

Ensuring food security has long been called the No.1 national strategy. The definition of food security by the Food and Agriculture Organization of the United Nations (FAO) includes four elements: (1) Availability; (2) Accessibility; (3) Utilizability; (4) Stability.

In China, the development of biomass fuels does not conflict with food security. The Chinese government has always attached great importance to food production and has always given top priority to food security. The development of biofuel is carried out under the premise of ensuring national food security. The fundamental principle of developing biomass industry is not to compete with agriculture for food and land.

In the early stage, the raw materials used by China's biomass industry were mainly grains produced in excess in the late 1990s. This not only solves the problem of local and temporary difficulties in selling grain, protects farmers' enthusiasm for growing grain, and acts as a dynamic regulator of grain production. On the one hand, from the perspective of grain structure, wheat and rice as rations have achieved absolute security. Corn is mainly used for feed grain and industrial grain, and a small part is eaten. China is basically self-sufficient in grain with 90% of total grain production. In China, food mainly includes grains, beans and tubers. Food production in China is dominated by grains. Grains include wheat, rice and corn, the three main grains, as well as sorghum and millet. Of the three main grains, wheat and rice are commonly referred to as rations. Only a small part of corn is eaten, and most of it is used as feed grain and industrial grain.

China's national condition is that the population is large but the land is small, and the agricultural production resources for food development are limited. In the long run, China will no longer increase the production of biomass fuels using grain as raw materials, but turn to the development of non-edible biomass resources, such as rapeseed, tubers, sugarcane, corn straw, forestry waste, waste oil, rice bran, etc. Moreover, a large part of rape is a winter crop in China. China has about 9×10^6 hm^2 of vacant field in winter and summer every year. If it is used to grow rape, it will not affect the production of rice and other main grain crops. Moreover, rape is a crop of land and cultivation, which has the function of fertilizing the field and resisting disease, and can increase the yield of rice and other succeeding crops by about 10%. In addition, high-yield energy crops, such as jerusalem artichoke (*Helianthus tuberosus* L.), sorgo, sweet potato and cassava, are planted on barren hills and slopes, saline-alkali land, deserted beach and sandy land, which not only do not occupy valuable cultivated land resources, but also provide a large number of raw materials for production, and help to improve the ecological environment and increase farmers' income.

3 The Impact of Biofuels on Food Prices

One of the main reasons for concern that the development of the biofuel industry threatens food security is that the use of food in the production of biofuels such as ethanol will greatly increase the price of food, making it difficult for more people to consume enough food because they do not have enough purchasing power. However, in the long run, the increase of demand will drive the expansion of industrial production scale, and whether the expansion of industrial production scale will improve the equilibrium price depends on the nature of the cost function of the industry. According to FAO research, it is sufficient to use arable land and other natural resources globally to increase agricultural output. The biggest problem in China is mainly the issue of “land abandonment”, and the long-term issue of 'fuel and grain competition for land' does not exist. Therefore, the increase in production scale will not have much impact on costs, and thus on food equilibrium prices.

At the same time, with the rapid development of industry, agricultural technology has a potential promoting effect on food production efficiency that cannot be underestimated. The first is to save land, labor and water resources, and the second is to change the natural environment of food growth, such as soilless cultivation, artificial synthesis and other ways, will increase the food supply without raising the equilibrium price. In short, the development of the biofuel industry has a limited effect on rising food prices.

Food as the main agricultural products, so far is still a necessity for human survival. Therefore, both the income elasticity of demand and the price elasticity of demand for food are small. In addition, the irreplaceability of food and the rigidity of demand time determined by the law of life further reduce the elasticity of food demand. According to the International Food Policy Research Institute (IFPRI) of USA, between a quarter and a third of the recent increase in the price of agricultural commodities worldwide is due to the production of biomass fuels.

4 The Impact of Biofuels on the Environment

The production of food fuels also has an environmental impact. First, the production of food fuel requires a large amount of land, water and agricultural production factors such as fertilizers, which can lead to extensive land destruction and ecological environment damage. Secondly, the production of food fuels also produces large amounts of greenhouse gases, which will exacerbate the process of global climate change. In addition, large-scale food fuels production will also cause some damage to the ecosystem.

Food fuels are less energy efficient than fossil fuels. This is because the production of food fuel requires the use of a large amount of energy, such as fertilizers, pesticides, machinery, transportation, etc., and the consumption of these energy will also cause the cost of food fuel to rise. In addition, food fuels are less energy intensive, meaning that more food fuels are needed to produce the same amount of energy. Some ecologically harmful chemicals may also be used to increase fuel production.

It is estimated that about 2.8×10^9 t of biomass can be produced annually from crop residues in China, and more than 1.5×10^6 t of bioethanol can be produced from energy crops, which is far higher than the current national annual production of fuel ethanol and the production target of 4×10^6 t per year by 2020. In terms of environmental impact, substituting biofuels for fossil fuels can greatly reduce greenhouse gas emissions and air pollution (such as particulate matter). However, the impacts of biofuel production on biodiversity, water quantity and water quality are subject to considerable uncertainty due to differences in feedstock types, land sources and management practices. Improved agricultural management and landscape planning can help protect ecosystem services.

5 Summary and Prospect

The biofuel market is becoming an emerging market on a global scale, driven by government and market-led trends. As a kind of biofuel, grain fuel although has the advantages of renewable, environmental protection, but there are some problems. First, the production of food fuels has an impact on food prices, which will have an impact on people in poor areas. Secondly, the production of food fuels also has a certain impact on the environment. Finally, the low energy efficiency of food fuels poses a challenge in replacing traditional fossil fuels.

In the future, with the continuous development of biofuel technology, grain fuels may be gradually replaced by other biofuels that are more environmentally friendly and sustainable. At the same time, the government should also strengthen the supervision of food fuels production, to avoid a large impact on the food market.

Biofuels are just one option for various renewable energy sources. As an alternative energy source, it has its limitations and cannot be the main alternative energy source, let alone the only alternative energy source. We should adjust measures to local conditions and take bioenergy as a link of energy diversification. Each country should clarify its financial situation, calculate its optimal energy structure for the next few decades or even longer, and then implement corresponding policy measures to achieve this. Developing renewable energy is an effective way to improve people's livelihood, maintain energy security and reduce greenhouse gas emissions. The economics of renewables themselves are closely tied to the price of fossil energy, notably oil. In the short term, significant economic benefits may be generated. However, if resources are exceeded, the production of biofuels is blindly promoted and the biofuel target is set too high, even if there is no competition with domestic food land, the shortage will be transferred through the import of biofuels, which will have a negative impact on regional and global food security. Under the premise of ensuring food security, countries should actively expand the raw material sources and comprehensive utilization of biofuels, gradually reduce their dependence on world oil resources, and make due contributions to the development of the international community.

Although there are some problems with food fuels, in the long run, the production and use of biofuels have enormous potential for society, the environment, and the economy, which can promote sustainable development. In order to promote the healthy and sustainable development of the biofuel industry, it is necessary to consolidate the stability of food supply, innovate biofuel production technology and promote the application of new fuels to reduce environmental pollution and carbon emissions in the production process. In addition, a global institutional framework is also needed to encourage a shift from biofuel production to non-food agricultural and waste production to avoid competition for food and ecological space and to achieve the sustainable development goals. We believe that with the joint efforts of all parties, the production and application of biofuels will embrace broader prospects for development.

Authors' contributions

ZJY was the executor of this study, responsible for the literature collectionr, writing of the paper and finalization; WZR was responsible for paper translation; DDY and LCC were responsible for revision and proofreading. All authors read and approved the final manuscript.

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