

Potato as a Staple Food in China: Issues and Solutions

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Abstract: The Ministry of Agriculture of the People's Republic of China (MOA) has announced that potato will soon be the newest staple food in China. Potato tubers are a rich source of starch, high-quality protein, essential vitamins, minerals, and trace elements, but many problems need to be solved to upgrade potato culturally, technically, environmentally, and economically to a staple food status in China. Overcoming these problems requires the use of domestic and international experiences and technical strategies as references; expanding the potato-growing areas at the expense of the ecological environment is undesirable. Inner Mongolia, northwest China, and southwest China, the major potato production areas, are not suitable for continued expansion of the potato-growing areas because this process causes grassland desertification and soil erosion, and the government has proposed that some farmlands be returned to grasslands or forest. In southern China, cultivation of potatoes in fallow fields in winter is the most promising method for increasing China's potato production and is worth promoting by the government. In addition, some technical issues need to be solved, such as how to develop potato into a Chinese traditional staple food, how to use dehydrated mashed potatoes as a semifinished food product, how to improve dry matter content of potato tubers, and how to process potato into a semifinished food product at a low temperature.

Key words: potato; staple food; China; ecological environment; dietary culture

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中国马铃薯主食化面临的问题及解决方法

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摘要: 农业部宣布马铃薯将成为中国新的主食, 马铃薯块茎富含淀粉, 高品质蛋白、重要维生素、矿物质和微量元素, 然而, 将马铃薯升级为中国的主食需要从文化、技术、环境和经济等方面解决很多问题。克服这些困难需要借鉴国内外的经验和技術, 以牺牲生态环境为代价扩大马铃薯种植面积是不可取的。内蒙古、西北和西南地区作为中国马铃薯主产区, 不适合继续扩大马铃薯种植面积, 因为已经导致了草原荒漠化和水土流失等问题, 政府已经提出要退耕还草或者退耕还林。在中国南部, 利用冬闲田种植马铃薯, 是最值得推崇的增加中国马铃薯产量的方法, 也是最值得政府推广的方法。另外, 将马铃薯开发成中国特色的主食如面条和馒头, 使用脱水马铃薯泥作为半成品原料, 提高马铃薯块茎的干物质含量, 采用低温干燥方式将马铃薯加工成半成品原料等技术问题需要解决。

关键词: 马铃薯; 主食; 中国; 生态环境; 饮食文化

1 Introduction

According to county annual records of XingPing county in Shaanxi Province, potato (*Solanum tuberosum* L.) was introduced in China in the 16th century. Historical accounts indicate that potato acted as a

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life-saving staple food in China during 1960s famine. So far, potato-producing areas in northwest and southwest China's poor rural areas still use the potato as a staple food. Therefore, most Chinese people still consider potato as a vegetable side dish^[1] or a staple food only for poor people.

Recently, the Ministry of Agriculture (MOA) announced that potato will soon be China's newest staple food^[1]. The main reason behind is the food security, as the population increase, China needs to grow more food to feed its people. Additionally, compared with staple crop rice, wheat and corn, grow potato doesn't require much water, and some poor soil can be used to grow

potato.

After one year on Feb. 23, 2016, the MOA again released an official document that China will further boost potato production to make the potato one of the nation's staple foods, next to rice, wheat and maize (http://news.xinhuanet.com/english/2016-02/23/c_135124181.htm). According to the MOA, 30 percent of the potato annual production will be consumed as a staple food by 2020, with potatoes being turned into noodles, steamed bread and other staple food products. The MOA considers making a distinct increase in potato production in the next few years: double potato planting area by 2020.

FAO has long listed potato as the fourth staple food; however, many problems need to be solved to upgrade potato culturally, technically, environmentally and economically as a staple crop in China. China's seed potato production is currently unorganized; only 20% of seed potatoes are of high quality^[2]. China lags in potato storage and processing technology; food culture restricts staple product types' development. Inner Mongolia and northwest and southwest China, major potato production areas, are unable to continue expanding potato planting as it causes grassland desertification and soil erosion and the government has warned that some farmland should be returned to grassland or forestry. Dehydrated mashed potato's price is nearly three times that of wheat flour in China; therefore, average people cannot afford and costs need to be reduced for it to become a staple food.

Overcoming these problems requires sharing experiences and technical strategies nationally and internationally, rather than allowing this plan to just stay in the slogan. Upgrading potato to become a new staple crop in China requires innovation in the potato industry, including seed and commercial potato production, storage and processing, and circulation of potato and derived products; cost of production and market risk also needs to be reduced. In addition, scientists in China must cooperate with government to educate public on potato nutrition and overcome the notion that potatoes are only 'food for the poor'.

2 Potato nutrition and food culture

Potatoes are rich sources of high-quality protein, essential vitamins, minerals and trace elements^[3,4]. Some

food scientists believe that potato and milk can satisfy all nutritional human body needs, and some agricultural experts believe that due to the rapid growth of global population, 'if a food crisis should happen in the future, only potato can save the human race'. Potato tubers contain high levels of essential amino acids, including lysine, leucine, threonine, phenylalanine and valine^[5]; this means that staple foods low in lysine, e.g., wheat and rice, can be supplemented in mixed diets with potato to provide an improved amino acid balanced diet.

However, many people in China are not aware of the potato's nutritious value. Chinese food includes a large variety of ingredients^[6], there is a saying (a bit exaggerated): "the Chinese eat everything with four legs, except for tables, and everything that flies, except for airplanes". Actually, Chinese food culture has used water as a medium for cooking for more than 2000 years, including steaming and boiling. The food staples cultures are fixed mainly particle and powder, i.e. steamed rice in the south and flour (steamed bread and noodles) in the north^[7], both need to use chopsticks. Most Chinese consider potato to be a vegetable, cooking 'hot and sour potato silk' for table use in their kitchen at home, with daily energy provided mainly through rice or flour.

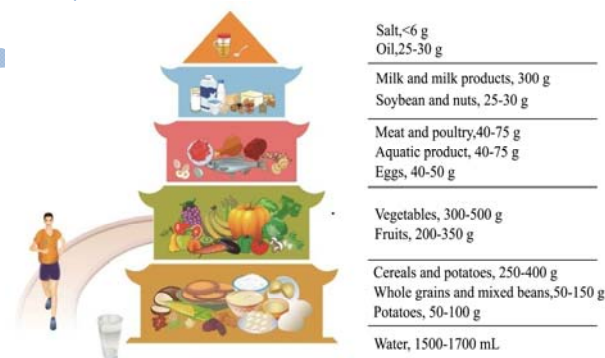


Fig.1 The Food Guide Pagoda for Chinese Residents^[8]

In 2016, the Chinese government has produced a new revised version of the Dietary Guidelines for Chinese Residents^[8] and the Chinese Food Pagoda (Fig.1), as guidance for dietary intake among its population. The dietary guidelines for the general population form the core of the guidelines^[9]: a) Eat a variety of foods, with cereals as the staple; b) Balance eating and exercise to maintain a healthy body weight; c) Consume plenty of vegetables, milk, and soybeans; d) Consume an appropriate amount of fish, poultry, eggs, and lean meat; e) Reduce salt and oil, and limit sugar and

alcohol; f) Eliminate waste and develop a new ethos of diet civilization.

In Europe and America, potato is a staple food, with an average annual consumption of potato per capita in Europe in 50~60 kg and up to 170 kg in Russia. In these countries, fast food is highly developed and consumption of frozen chips is widespread; annual production of French fries in the US is more than 17.4 billion pounds and constitutes almost 44% of total processed potato^[5].

Many Chinese children in urban areas like to eat French fries^[10]; however, most parents warn their children against eating them as it is considered as junk food^[11]. The concept of 'junk food' is from the West, but Westerners realize that 'there is no such thing as unhealthy food, only unhealthy diets'. Many Chinese people still reject French fries. Total French fries' oil content is almost 15%^[12], and many food types have even higher oil content. The Chinese government should seriously consider whether French fries can be listed as a staple food as the technology for industrialized production of French fries is already well developed.

3 High production, but low processing ratio

Total potato production was 381.68 million tonnes worldwide in 2014 and China is the major producer, with 95.57 million tonnes, accounting for 25.04% of world total^[13]. Major potato-growing areas in China are Gansu, Sichuan, Inner Mongolia, Guizhou, Yunnan and Chongqing and they account for 65% of total potato-growing areas in the country^[14].

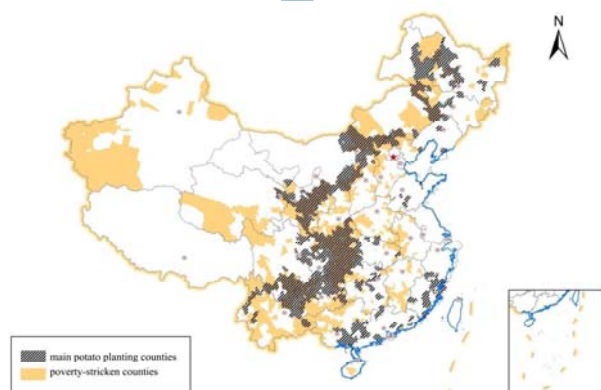


Fig.2 The statistical map of China's main potato-planting counties and poverty-stricken counties

Note: Provided by Professor Qiyou Luo, Chinese Academy of Agricultural Sciences.

At present, more than 70% of potato-growing areas are distributed in national-level poverty-stricken counties

in China; among 592 key poverty reduction counties, 549 counties grow potato (Fig. 2). Poverty-stricken counties are mainly concentrated in areas of poor natural conditions, drought, low temperature and poor soil^[15]. With limited government revenues and lack of potato processing plants, potatoes are typically transported to big cities, such as Beijing, Shanghai and Guangzhou, for fresh food.

In North America and some European countries, between 50% and 60% of potato is processed^[16]; however, in China, this value is about 10%, and almost half of that is processed into starch^[14]. The potato starch processing capacity is more than 1.2 million tonnes, although actual annual processing is around 600,000 tonnes. Generally, potato starch processing in China does not use specific potato varieties; some domestic companies process small and decayed potatoes and those not suitable for fresh consumption into starch. As a result, the yield and quality are quite low.

China also produces frozen French fries, potato chips and dehydrated mashed potatoes^[17]; however, the proportions are too low to compare with total production of processed potato products for the national population. According to 2014 statistics from the China National Food Industry Association, nationwide processing capacity is around 296,000 tonnes of French fries, 281,000 tonnes of dehydrated mashed potatoes and 100,000 tonnes of potato chips. These products are usually made by large companies or multinational enterprises, with fixed potato varieties, and assorted farm management technology is used. Due to growing technological demands and higher processing costs of special potato varieties, average farmers in China refuse to grow them. Therefore, lack of feedstock potato, low production rate, high cost and market capacity have constrained potato-processing enterprises' development.

The Chinese government has long considered improving potato processing levels and turning potatoes into staple food has created new opportunities, which means processing potato into foods that Chinese are accustomed to, such as steamed bread and noodles, will help to change it from being a supplementary food into a basic food, eventually making it the fourth-ranking staple food in China.

4 Different challenges and potential solutions

4.1 Ecology

Vast grasslands have long symbolized Inner Mongolia and as China's most important animal husbandry base, continuing to expand the potato planting area is not optimistic^[18]. Expanding this area at the expense of ecological environment is undesirable, and overuse of grassland and water resources to grow potatoes will intensify grassland desertification, irreversibly damaging the ecological environment.

Arid and semi-arid regions of northwest China are ecologically fragile^[19]. At Gansu and Ningxia, drought less plateau areas are most important potato-producing areas, and planting potatoes saves more water than any other food crops; however, agricultural water use is not currently sustainable^[20], and continuous expansion of potato-planting areas will lead to more serious soil and water loss and deterioration of ecological environment (Fig. 3). High altitude areas of mountainous southwest China are cold and suitable for growing potatoes; however, many years of deforestation have led to serious soil erosion and rocky desertification and even triggered landslides. Lacking of conservation of natural vegetation and ecological maintenance of forests has resulted in seasonal drought in many mountainous areas^[21]. Without ecological assessment and suitable planning, continuing to expand potato-planting areas will result in unimaginable consequences.



Fig.3 In the arid and semiarid areas of northwest China, potatoes are grown with a plastic film to save water

Note: Provided by Professor Jian Wang, Qinghai Academy of Agriculture and Forestry Sciences.

Of late years, the potato-planting industry has developed quickly in southern China^[22], especially in Fujian, Hunan and Guangdong; these areas mainly plant potatoes in fallow fields in winter (Fig. 4). According to the statistics from South China Agricultural University,

from October 2012 to March 2013, 200,000 hectares of fallow fields were used to grow potato. This cultivation mode is environment friendly and without farmland competition for other crops; it is the most promising method for increasing China's potato production and is worth promoting by the government.



Fig.4 Fallow fields being used to grow potatoes in winter in southern China

Note: Provided by Professor Xianwei Cao, South China Agricultural University.

4.2 Food application

In 2015, some Chinese research institutes have claimed that they have successfully developed steamed bread containing 40% potato flour and noodles with 35% potato flour. They used dehydrated mashed potato to partially replace the wheat flour; however, adding more potato will result in noodles with a tendency to break and bread that is difficult to form and ferment and is too hard to eat.

In 2016, hundreds of varieties of staple potato products with local ethnic characteristics have sprung up all over the country. However, how to achieve industrialization and standardization of production is the need for long-term efforts.

Actually, using potato flour as partial replacement of wheat flour in bread has been reported previously^[23,24]. The highest level of 10% of potato flour to replace of wheat flour were used in two researches: Yanez et al.^[23] reported that the substitution of wheat flour produced increases in water absorption, loaf weight and loaf volume as compared to all-wheat bread, Ijah et al.^[24] concluded that the use of hydrated potato flour in bread making is advantageous due to increased nutritional value, higher bread yield, and reduced rate of staling.

4.3 Chemical properties

Because dehydrated mashed potato involves high-temperature processing^[25], protein denaturation and starch gelatinisation, rheological characteristics and microstructure and mechanical properties of wheat dough will be adversely affected. The temperature for potato protein denaturation and starch gelatinisation is about 70 °C^[26-28]; potato processed at lower temperatures into a semi-finished ingredient may improve processing properties of dough.

When a mixture of wheat flour and water is kneaded, cysteine residues undergo sulfhydryl-disulfide interchange reactions, resulting in extensive polymerization of gluten proteins^[29-35]. Potato tuber contains relatively high quality protein (about 3%~6% of dried weight); however, sulfur-containing amino acids are low, with methionine and cysteine accounting for 1.20%~2.15% and 0.20%~1.25%, respectively^[36]. Sulfur-containing amino acids in potato can be enhanced by molecular breeding; genes isolated from other plants can be used^[37].

4.4 Breeding

To develop potato into Chinese staple foods, such as noodles and steamed bread, using dehydrated mashed potato as a semi-finished product, the technical problem of improving the dry matter content of potato tuber needs to be overcome. At present, the dry matter content is about 20% in China's main potato varieties using conventional cultivation techniques for potato tuber production. If the dry matter content can be increased to 30%~40% through breeding and cultivation, the cost of dehydrated mashed potato will greatly reduce. When the cost of dehydrated mashed potato processing is closer to that of wheat flour processing, taking into consideration the nutritional advantages of potato, it is entirely possible to realize the plan of "potato staple food" in China.

5 Outlook

Today, although many Chinese people still believe in handmade food, its proportion in future will be decreased; this is a historical trend and not man's choice^[39]. Turning potato into a staple food is a demand of the national food security strategy; the most basic responsibility of food security is to ensure food quantity for Chinese people, followed by ensuring that food is

nutritious, safe and convenient.

Upgrading potato to a staple crop through scientific and technological innovation requires (1)improving ordinary people's potato nutrition awareness, (2)expanding potato-planting areas and enhancing potato production without destroying environment, (3)facilitating industrialization of traditional Chinese potato-related products using modern food processing technology and (4)strengthening policy support for potato processing by increasing scientific research projects on potato as a staple food.

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现代食品科技