

# How Food Consumption Trends are Changing the Direction of Broiler Breeding

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## Abstract

Scientific development is based on the material needs of society, and breeding staff set breeding goals by anticipating the future market. With rapid changes in production levels and consumption trends, breeders in the broiler industry respond to changing consumption trends by continuously adjusting their breeding objectives. With the rapid growth in protein consumption demand, China has become a major producer and consumer of broilers, and the broiler breeding industry has achieved considerable success. This paper reviews the development of China's broiler industry and changes in breeding efforts and summarizes the factors of broiler breeding changes in China to elucidate the changes in broiler breeding direction. At the same time, the change in the direction of chicken breeding is used to reflect the improvement of the food consumption capacity of the Chinese people and the change in the direction of consumption.

**Keywords:** Breeding; Food consumption; Broiler; Chicken meat market

## Broiler Production in the Context of Changing Global and Regional Consumption Trends

### Global trends

The livestock industry, which is undergoing changes in global and regional consumption trends, shows the development dynamics of many aspects, including population growth, economic development, changes in consumption habits and technological advances and other factors of integrated impact, in which the demand for food consumption is one of the key factors driving the development of agriculture and animal husbandry. As the world's population grows and the standard of living improves, people have higher demands regarding the quality and class of food. Among many food products, chicken is one of the most consumed meats in the world due to its low production cost, high protein and low-fat content. Poultry meat has grown at an average rate of 5% over the past five decades, significantly faster than beef at 1.5%, pork at 3.1% and small ruminants at 1.7%, with poultry production in developing countries growing at up to 7.4% per year. With the world population projected to reach 9.8 billion by 2050, global demand for animal products is projected to increase by 70% [1], with demand for eggs increasing by 65% [2], and demand for poultry meat projected to increase by 121%, well above beef's 66% and pork's 43% [3]. Rapid growth in demand is expected to continue to improve production performance as the main breeding objective for the poultry industry at this stage. The growth rate of commercial broilers increased by 400% from 1957 to 2005, with a 50% reduction in feed conversion ratio [4].

Global chicken production can be divided into two major categories: large-scale factory farming, which large companies lead in regions with high levels of agricultural modernization, and small-scale farming in regions with low levels of agricultural modernization. Small

breeding companies cannot withstand the boom-and-bust cycle and are gradually going bankrupt and being merged with large companies [5]. However, this centralization has the potential to engender crises, such as the absence of sweat glands in traditional poultry, which renders them vulnerable to heat stress. High-density feeding results in diminished immunity, thereby increasing the risk of various infectious diseases. The environmental damage caused by large-scale breeding is another persistent problem that limits the further expansion of large-scale chicken farming. The economic viability of chicken farming is attributable to its low production cost, initial investment and excellent feed conversion rate [6]. Industry plays an important role in alleviating poverty, providing income and access to markets in economically disadvantaged areas [7,8], thereby driving the growth of livestock production in such regions. Food protein utilization of poultry meat and eggs is significantly higher than that of ruminants and aquaculture [9], substantially enhancing the dietary structure of economically disadvantaged regions. In most developing countries, smallholder poultry accounts for 30-80% of the total poultry population and contributes about 98% of the village consumption of poultry products. Different cultural and religious requirements and restrictions influence the consumption patterns of specific food products. In contrast, chicken and eggs can be widely consumed in all regions of the globe, with almost no taboos, meaning that the chicken industry is able to produce on a large scale in areas with high industrial levels, while also utilizing small-scale production inputs in less developed areas [10]. Currently, the number of chicken products in developing countries has surpassed that of developed countries [8], effectively improving the status quo of animal production in various less developed regions of the world.

### Chinese trends

Chickens have long been used as one of the world's main agricultural species and are the most abundant domesticated livestock in the world and China. By 2022, the global poultry industry is projected to produce 120 million tons of meat and 1.65 trillion eggs annually [11]. China is set to contribute 0.15 tons of chicken meat and 0.59 trillion eggs, accounting for 12.1% and 35.8%, respectively, of the world's largest and third-largest chicken meat producers, thereby establishing it as the world's foremost egg producer and the third largest chicken meat producer. A total of 2,465 chicken breeds are recognized worldwide, with China, as one of the origins of domestic chicken, boasting 146 breeds [11]. This diversity can be attributed to the country's complex geographical environment and ecological conditions, as well as the long-term process of natural and artificial selection [12]. Following the implementation of economic reforms and the opening up of the Chinese economy, the country witnessed the emergence of large-scale chicken farming, driven by the establishment of many Sino-foreign joint ventures and the introduction of advanced foreign management technologies and systems. This development marked a significant shift from the traditional, small-scale backyard farming model, leading to a transition to intensive, large-scale rearing practices. The industry has since experienced a period of

rapid specialization, with an average annual growth rate of 5.8% in chicken meat production over the past six decades. At present, China's professional laying hens are mainly farmed on a free-range basis, with a low level and limited number of specialized family farms, and less medium- and small-scale farming as well as large-scale factory farming. Nevertheless, China's professional broiler industry is characterized by a substantial degree of scale, with numerous large-scale broiler farms that have attained internationally advanced levels. Industry is undergoing a continuous process of development towards industrial concentration.

## Correlation between Broiler Breeding and Food Consumption Demand

### Modernization of the broiler industry

The domestication of chickens began approximately 10,000 years ago; however, despite this extended period, genome-wide diversity in chickens has not diminished. In fact, domesticated chickens possess a rich genetic resource base, indicating substantial potential for breeding advancements within the chicken industry [13]. Significant improvements in broiler performance can be attributed to the industry's efforts in developing new varieties. According to Havenstein [14] and others, genetic selection by commercial breeding companies has accounted for 85-90% of the changes in broiler growth rates over the past 45 years, while nutritional contributions have contributed only 10-15%. On the demand side, increased poultry meat consumption has been a key driver, while on the supply side, developing countries have emerged as global competitors in the agribusiness sector. Historically dominated by developed countries, the dynamic world poultry market is now increasingly led by developing nations [15]. There is a clear trend towards consolidation and concentration of breeding units in developed regions, with a shift towards large-scale and intensive operations. Intensive selection and breeding have resulted in unprecedented efficiency in animal breeding systems [16], making it essential to employ efficient breeding methods to meet the rapidly evolving demands of the food industry. However, research also indicates growing consumer interest in non-intensive, organic, and free-range chicken meat [17].

The modernization of the broiler industry has enabled the large-scale and purposeful breeding of broilers. The practice of balanced, holistic breeding is a contributing factor to the sustainability of the broiler industry. This is since breeding improvements are permanently accumulated from generation to generation and are widely disseminated throughout the poultry supply chain [18]. The incorporation of novel recording and analytical methodologies for more precise prediction of genetic values has the potential to enhance genetic sustainability and welfare improvements while addressing trait trade-offs. It is imperative to consider economic and social projections when formulating breeding objectives, as breeding is a long-term endeavor. The objectives of breeding will vary according to market segments and regions, and the diversity of broiler production patterns and consumer demand will determine the direction and focus of breeding objectives. Broiler breeders are

required to follow current market demands and then lead the way in consumption.

### **Demand and supply of chicken food products**

As societal demand for animal products increases, the mode of production in the livestock sector is undergoing change. The increase in social demand for food products has compelled the agricultural sector to evolve in the direction of intensification, resulting in the marginalization of the breeding of indigenous, conservative breeds and contributing to the continuous concentration of the genetic advantages of traditional breeds towards commercial breeds in breeding efforts [19,20]. As demonstrated data from the National Bureau of Statistics of China indicates that the stability of poultry meat prices significantly exceeds that of other livestock meat products. According to the statistical model developed by Wang Jating [21], China has maintained a high level of self-sufficiency in poultry meat, with a consistent trend of self-sufficiency within the domestic market. However, the surge in imports of chicken products from overseas in recent years has led to a decline in the rate of self-sufficiency. This decline reflects the rapidly growing consumer demand for broiler meat in the Chinese market. In the context of China's internal unified market, a substantial positive correlation has been observed between the price of chicken meat and that of other livestock meat products [22,23]. Given that chicken meat accounts for the majority of China's poultry meat consumption, it can be deduced that the broiler industry plays a positive role in stabilizing meat prices in China.

### **Two Tracks of Broiler Breeding**

#### **White-feather broilers, yellow-feather broilers and broiler hybrids**

In China, the classification of broiler chickens is based on two primary categories: white feather and yellow feather. The white-feathered broiler is a strain selected from White Plymouth rock, whose white feathers are a recessive trait, also known as recessive, white-feathered chicken. White-feathered broiler has been identified as the breed with the highest feed conversion rate and the highest degree of large-scale farming of all livestock and poultry breeds. It exhibits advantages such as a rapid growth rate and high production efficiency, and it is responsible for approximately 70% of global chicken meat production. Additionally, the meat of white-feathered broilers is characterized by enhanced tenderness, making it particularly well-suited for large-scale industrial food processing [24]. This meat is predominantly marketed to major restaurant chains such as KFC and McDonald's. Yellow-feather broilers represent a distinctive Chinese local variety of poultry, primarily consumed by domestic consumers. In comparison with white-feather broilers, yellow-feather broilers exhibit several advantageous characteristics that are more aligned with the consumption habits of Chinese consumers. These include a decent body weight, a prolonged growth cycle, a delicious slice of meat, and strong disease resistance. These characteristics render yellow-feather broilers more suitable for Chinese home cooking [25]. Growth performance, carcass conductance, and metabolic

composition of chicken muscle also differ among different breeds. White-feathered broilers have been shown to exhibit higher feed efficiency, greater breast and thigh muscle yield, and a reduced abdominal fat percentage when compared to yellow-feathered broilers, so it can be widely cited when the economy is wild. Furthermore, significant differences in the concentration of flavor precursors such as polysaccharides, amino acids, and organic acids have been identified among different types of industrial broilers available in the market [26].

Significant differences exist between yellow-feather and white-feather broiler farming patterns, particularly about rearing methods, growth rates, feed conversion ratios and market positioning. Typically, yellow-feather broilers are raised in two distinct rearing methods: the fast cage method, which lasts two months, and the slow free-range method, which lasts four months. These methods offer different rearing times and price options. Conversely, white-feather broilers are often reared in a more commercially oriented manner on a larger scale, to enhance productivity and reduce costs. The consumption behavior of broilers is influenced by various factors, including the breeding method, price, dietary cleanliness labeling, and rearing time. According to the statistics and analyses of Xu [27], rearing had the strongest baiting effect, suggesting that consumers in China preferred the nutritional value and taste of free-range chicken. Furthermore, the production and consumption of both types of broilers exhibit regional disparities, manifesting as a north-south divide, with white-feather broilers being farmed and consumed more extensively in the northern region [28] and yellow-feather broilers predominantly present in the south [29]. This geographical distribution may be associated with regional dietary habits and environmental factors. We can further broaden the topic by saying that behind the fierce competition between White-feather broilers and yellow-feather broilers reflects the struggle between the two consumer tendencies (local and Western) in China's path of radical modernization.

In addition to the two main categories of white-feather and yellow-feather broilers, a variety of hybrid broilers are present in the Chinese market. The generic term "Chinese broiler" is used to refer to locally raised hybrid breeds that possess distinctive meat and nutritional characteristics. These birds are raised over a longer period and usually grow slower than commercial broilers. This contributes to the higher quality of their meat. Furthermore, Chinese consumers have a variety of culinary traditions and preferences, involving the preparation of chicken in a variety of ways and with strong local flavors. These characteristics have enabled "Chinese broilers" to retain a competitive advantage and a stable market position in local markets.

#### **From meat production to meat quality**

To cope with the fast-changing food consumption demand in China, the industrial structure of the broiler industry has been continuously adjusted. Yellow-feather broilers, as a local breed in China, have been unable to cater to the fast-growing market since their meat production efficiency is not as good as that of imported white-feather broilers, and this has led to a continuous decline in

overall production in recent years. But at the same time, from the yellow-feather broiler within the structural changes, the proportion of fast-type declined, medium-speed type is relatively stable, and focuses on meat quality, not in line with the traditional market requirements of the slow type of proportion is increasing, which means that China's broiler consumer market, the high efficiency of low price of fast-growing broilers, and the high quality of high-price slow-growing broilers show parallel dual development. Fast and large broilers have poorer meat quality, as shown by thick muscle fiber, reduced intramuscular fat, PSE meat, an increased proportion of heterogeneous meat represented by lignified meat, and poor tibial development; whereas local Chinese yellow chickens, although having more favorable meat quality in the domestic market, have slower growth rates, lower muscle yield, lower feed conversion ratio, poor slaughter performance, and higher accumulation of abdominal fat. How to choose between meat quality and meat quantity is the most important issue for Chinese broiler breeders in their breeding practice.

### Breeding for sustainability

Sustainability is of paramount importance in broiler breeding, which is related to the balance between the economic, environmental and social dimensions of broiler farming [30]. Breeding goals should be scaled up in a balanced manner, focusing on productivity and efficiency, and simultaneously constrained by agricultural resources, environmental loads and animal welfare, as well as possible limitations imposed by genotypes such as environmental interactions, antagonisms between traits and potential selection constraints.

Future breeding focus areas will need to include continued reduction in the demand for resources such as land, energy and water through sustained improvements in efficiency; reduction in the use of certain chemicals such as antibiotics, pesticides and fertilizers; improvement in flock immunity; and general improvements in animal production welfare [31,32]. By taking these factors into account, the broiler farming industry can achieve long-term sustainable development while meeting market demands.

### Brief History of Broiler Breeding in China

#### Breeding policy

To meet the rapidly growing consumer demand, increasing yield and reducing costs have been the absolute mainstay of broiler breeding in China, and improvement of production characteristics such as growth performance, feed conversion ratio, and meat quality have always been established as the most important breeding objectives [33]. To meet the increasing demand for dietary protein, the poultry industry has used genetic selection to increase broiler growth rates by more than 400% over the past 50 years. Although modern broilers reach a market weight of 2kg in as little as 35 days, twice as fast as broilers 50 years ago, this accelerated growth has been accompanied by a variety of deleterious consequences. For example, in addition to cardiac and musculoskeletal problems that are a direct consequence of weight gain, the immune response of

modern broilers is thought to have changed [34], and the unintended consequences of the selection process are a persistent challenge to the broiler industry because, no matter how comprehensively a selection program may have been specified, exceptions continue to be made when breeding practices are carried out [4]. Thus, it is not only shifts in food consumption trends outside the breeding farms that determine the breeding approach, but also problems that have accumulated within the breeding farms over time.

#### Breeding history

In the middle of the 19th century, local Chinese chickens used to lead the world in egg laying and meat production performance. For example, the British introduced China's Jiangsu, Shanghai, Langshan chickens and Jiujiu yellow chickens, and then introduced from the United Kingdom to the United States, after breeding in both countries is recognized as a standard breed. Langshan chicken is recognized as a part-time breed, and Jiujiu yellow chicken is recognized as a meat breed. These breeds have had an important impact on the formation of some world-famous livestock breeds, such as the British Orpington and Australian Black, which have been introduced to China's Langshan chicken blood. Plymouth Rock, Rhode Island Red, and other breeds of Chinese Jiujiu yellow chicken as breeding material [35], which shows that China's indigenous chicken breeds have ample potential for development.

In the early stages of reform and opening, China's broiler industry mainly imported foreign white-feather broiler breeds, such as Ross and Hubbard breeders, which quickly dominated China's rapidly expanding internal market due to their advantages of fast growth rate, high feed conversion rate, and ease of processing. Grandparent breeders are introduced from chicks to culling in only about 1.5 years, after which production performance decreases and must be replaced, so grandparent breeders need to be introduced and renewed from developed regions of the breeder industry year after year [36], and the long-term large number of introductions not only threatens the security of China's broiler breeder industry, but also poses a challenge to the biosecurity of poultry. A few representative breeding achievements are described in the following section.

**Jinghai yellow chicken:** The Jinghai Yellow Chicken is the first new breed of high-quality broiler chicken in China to pass the official state certification, bred jointly by Yangzhou University, Jiangsu Jinghai Poultry Group Co., and Jiangsu Provincial Animal Husbandry General Station [37], and is a product of the university-enterprise joint policy implemented in China. In addition to the traditional good traits of excellent meat quality, early maturity, and high reproductive performance, this breed has remarkable adaptability to poor-quality feed and thus can be widely cited by small-scale chicken farms with rougher production environments [38], which is an important breakthrough in the field of broiler breeding in China.

**Guangming No. 2:** 'Guangming No. 2' is jointly bred by Foshan Gaoming District Xin Guang Agricultural Husbandry Co., Ltd. Beijing Animal Husbandry and Veterinary Research Institute of the Chinese

Academy of Agricultural Sciences (CAAS). Since the formation of the foundation flock in 2011, this breed has introduced and developed a variety of breeding technologies such as big data platform construction and phenotypic intelligence determination, and finally was officially released on December 8, 2021, at a conference jointly held in Beijing and Guangdong, marking a breakthrough in domestic white-feather broilers from scratch [39]. Through the citation of multiple new technologies, it has achieved a smooth path for broiler breeding and broken the long-standing dependence on foreign sources of white-feather broiler seed. Guangming 2 is suitable to produce split chicken meat, which is convenient to produce fast food, group meals, and deep-processed products, a characteristic that makes it more in line with the consumption habits of China's urban population.

**Huashan chicken:** The successful breeding of Huashan chicken is an important breakthrough in the field of poultry breeding in China. Huashan chicken is the first new breed of slaughtered and processed yellow-feather broilers in China, which is jointly bred by Jiangsu Lihua Herding Company Limited and Jiangsu Poultry Research Institute. The breeding of this breed fills the gap that yellow-feather broilers on the market are generally unsuitable for large-scale slaughtering and processing, and effectively supports the demand for large-scale breeding, centralized slaughtering, cold chain transportation, and chilled marketing in the poultry industry [40]. The breeding of this breed signifies the feasibility of traditional Chinese broilers in large-scale centralized breeding mode.

### New breeding methods

Modern chicken varieties of environmental adaptability are reduced, breeding is faced with the crisis of genetic resources, selection is faced with biological bottlenecks limitations and other issues, restricting the development of chicken breeding; on the other hand, the development of genetics, the wide application of computer information technology, the modern high-tech day by day, for chicken breeding provides many opportunities. In short, the rapid development of the modern broiler industry has put forward higher requirements for the progress of breeding science and technology. The birth of molecular marker technology in the 1980s realized the successful application of molecular genetics in broiler and layer breeding, and the development of molecular genetics has opened up a new world for the application of classical quantitative genetics in chicken breeding, and various cutting-edge tools have been accommodated in broiler breeding, which have made outstanding contributions to the breakthrough progress in global chicken breeding [41,42]. For example, Meuwissen [43] and others proposed a genome-wide selection approach, which applies genome-wide high-throughput SNP markers, combined with statistical methods such as GBLUP and Bayesian data, to estimate the genome-wide breeding values of the population to be tested, and to assist in the selection and retention of outstanding individuals. Chinese breeders have successfully developed a chicken whole genome SNP chip, which utilizes the rich poultry germplasm resources in China to quickly and accurately achieve targeted selection and breed new high-quality broiler varieties with China's

own brand name [44] and enhance the market competitiveness of domestically produced breeds. In addition to the introduction of new technologies, different and traditional measurement indexes and evaluation methods have also been iterated in the breeding practice to assist in the development of efficient broiler breeding strategies [45,46].

### Policy impact

The Chinese government has increased its financial and policy support for the broiler breeding industry by formulating and implementing relevant policies. The National Broiler Genetic Improvement Program (2014-2025) aims to form a commercial breeding model with core breeding farms as the main body, and to breed more than 38 new yellow-feather broilers by 2025. This shows that the Chinese government attaches importance to and supports the broiler breeding industry, which helps to promote the development of the broiler industry. The Chinese government encourages the establishment of a multi-level breeding system to promote the sustainable development of the high-quality broiler industry. This includes measures such as strengthening the protection of local chicken breed resources and genetic testing and systematically determining breeding directions and technical indicators. In addition, a proposal has been made to create a national broiler breeding core farm to pool resources and advantages and promote the progress and application of broiler breeding technology.

The Chinese government is also concerned about the environmental and social impacts of the chicken breeding direction. For example, studies have shown that modern chicken breeding has achieved significant results in mortality reduction, disease control, nutritional supply and good husbandry management, all of which are important aspects of improving poultry welfare [47]. At the same time, the government is also promoting environmentally friendly livestock farming to reduce the negative impacts of livestock farming on the environment.

### Conclusion

In this review, we explored how food consumption trends are influencing the direction of broiler breeding, particularly in China. Global broiler consumption continues to grow, especially in developing countries, and the broiler industry in China, a major producer and consumer, is developing rapidly. Breeding objectives have shifted from pure yield to a multi-directional focus on yield, meat quality, and sustainability, reflecting changing consumer demands. Huge market demand has guided China to make significant progress in broiler breeding, breaking its dependence on imported breeds and improving the competitiveness of the domestic broiler industry. This also reflects the fact that China has driven the development of related technology industries through its huge market. In the future, along with unpredictable changes in the market environment, broiler breeding needs to be prepared to breed in multiple directions, such as balancing yield and quality and coping with environmental changes and disease challenges. The diversification of market demands requires more diversified

breeding directions to meet the needs of different markets and consumers.

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