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RESEARCH ARTICLE

Strengthening the Long-Term Mechanism for Grain and Food Conservation: Strategic Priorities and Policy Recommendations

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Abstract

Strengthening the long-term mechanism for grain and food conservation is a key lever for safeguarding national food security in the new era. It matters for easing the tight balance between grain supply and demand, for withstanding the risk of international "decoupling and broken chains," for advancing green agricultural development, for transforming and upgrading the food system, and for securing reasonable returns for grain farmers. At present, the mechanism faces four obstacles: farmers have little incentive to save grain and reduce loss; operators store and transport grain without standard practice; processing enterprises are oriented in the wrong direction; and consumers are not sufficiently aware of conservation. In response, the whole industrial chain should be made loss-efficient, wasteful catering should be curbed across society, and a policy system for food conservation should be established and improved.

Keywords: food waste; food conservation; grain loss reduction; food security

1. Why a Long-Term Mechanism for Grain and Food Conservation Is Necessary

A persistent tight balance in grain supply and demand, the continuing risk of international "decoupling and broken chains," the growing priority of green agricultural development, the urgent need to transform and upgrade the food system, and the pressing need to raise farmers' incomes together make it imperative to strengthen the long-term mechanism for grain and food conservation in the new era.

Advancing grain conservation and loss reduction is an important measure for safeguarding national food security and an "invisible farmland" that increases the effective supply of grain. General Secretary Xi Jinping attaches great importance to grain conservation and loss reduction and advocates a social ethos of "strict economy and opposition to waste." He has made a series of scientifically grounded and important expositions on conserving grain, issued repeated important instructions and comments on advancing grain conservation and loss reduction and on curbing catering waste, and put forward a series of new viewpoints and new theses on "conserving grain, cherishing grain, and treasuring grain," forming a conservation outlook for the new era that is rich in theoretical content. In the new era, work on conserving grain and curbing waste has continued to advance at a high level, the top-level institutional system for grain conservation and loss reduction has become increasingly complete, and China's grain conservation and loss reduction work has entered a new era of rule-based governance.

Affected by the increase in extreme weather and climate events, intensifying geopolitical conflict, and other factors, global grain supply and demand face a "dilemma." On the one hand, inadequate grain supply has become increasingly evident. The report *The State of Food Security and Nutrition in the World 2024*, issued by the Food and Agriculture Organization of the United Nations (FAO), shows that in 2023 between 713 million and 757 million people worldwide faced hunger, an increase of about 152 million over 2019. On the other hand, global grain loss and waste remain severe. The *Food Waste Index Report 2024*, issued by the United Nations Environment Programme, shows that total global food waste reached 1.05 billion tonnes in 2022, or 132 kilograms per capita, accounting for about one-fifth of the food available to consumers. Global food shortages and food waste thus continue to coexist and remain a prominent problem.

As a country with a large global population, China has fed 17.4 percent of the world's population on only 8.5 percent of the world's cultivated land. Its achievements in safeguarding food security are remarkable, but its grain loss and food waste are also relatively severe, and the potential for conservation and loss reduction is enormous. On the one hand, China's grain loss and food waste are serious [1-2]. The *China Food and Nutrition Development Report 2023*, issued by the Institute of Food and

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Nutrition Development of the Ministry of Agriculture and Rural Affairs, shows that China's overall food loss and waste rate was 22.7 percent in 2022. Calculated on 2021 output, this amounts to 460 million tonnes of food lost or wasted, enough to meet the nutritional needs of 190 million people for one year. The loss rates at the stages of agricultural production, post-harvest handling, storage, processing, distribution, and consumption were 4.3 percent, 4.9 percent, 2.6 percent, 0.5 percent, 2.3 percent, and 8.0 percent respectively. On the other hand, the scope for grain conservation and loss reduction in China is enormous. The *China Agricultural Industry Development Report (2023)*, issued by the Chinese Academy of Agricultural Sciences, shows that by 2035, if China reduces loss rates at the stages of grain harvest, storage, processing, and consumption by 1 to 3 percentage points, losses of the three major staple grains will fall by 40 percent, saving 110 billion jin of grain—equivalent to a programme that raises grain production capacity by one hundred billion jin. Constrained by tightening resource factors, upgrading consumption patterns, and a complex and volatile international environment, and facing a medium- and long-term tight balance between grain supply and demand, China's room for increasing grain supply through "opening up sources" is limited. There is an urgent need to work on the "stemming of losses" side, to give equal weight to opening sources and stemming losses and to increasing production and reducing losses in parallel, and to do good work on grain loss reduction across the whole chain [3-4].

1.1 Grain Conservation and Loss Reduction as an Important Lever for Easing the Tight Balance between Grain Supply and Demand

Although China has had consecutive bumper grain harvests, its capacity to safeguard food security has continued to improve, and the Chinese rice bowl is held more steadily and securely than before, grain supply and demand nonetheless remain in a state of tight balance. In 2024 national grain output reached 1.413 trillion jin, an increase of 22.2 billion jin, or 1.6 percent, over 2023. Output climbed above the 1.4 trillion jin mark for the first time, giving the country sufficient capacity to safeguard food security. Calculated on a national population of 1.41 billion at the end of 2023, per capita grain output exceeds 500 kilograms, far above the 400 kilograms per capita food security line widely accepted in academic circles. Yet the tight balance between grain supply and demand remains pronounced, structural and deep-seated contradictions are prominent, and pressure to keep increasing output in future is considerable [5]. Since 2004, China's agricultural trade has shifted from surplus to deficit, and dependence on external sources has risen year by year [6]. Grain conservation and loss reduction helps reinforce the strategic goal of national food security. In 2022, China's post-harvest grain loss was about 54.24 million tonnes, equivalent to the grain output of 140 million mu of cultivated land [7]. Implementing grain loss reduction measures can therefore directly raise effective grain supply, which is of great significance for coping with the tight balance between grain supply and demand.

1.2 Grain Conservation and Loss Reduction as a Key Measure for Withstanding the Risk of International "Decoupling and Broken Chains"

At present, the tide of anti-globalization is rising, trade protectionism is growing, unilateral sanctions are being abused, and geopolitical conflict is intensifying. As a result, global grain supply chains have become increasingly fragile, uncertainty in the grain trade has increased markedly, and the risk to China's grain imports has continued to rise [8]. Since 1996, soybeans have shifted from long-term net exports to net imports, and the trend has been broadly upward year by year, driving a continuous expansion of the agricultural trade deficit. In 2004, China recorded an agricultural trade deficit of USD 4.64 billion, and the figure has risen almost continuously since then. In 2024, China's agricultural trade deficit reached USD 112.16 billion, and grain imports amounted to 157.53 million tonnes, or 22.3 percent of that year's total grain output. In structural terms, net soybean imports were 99.41 million tonnes, up 11.4 percent over 2023, accounting for 61.4 percent of all grain imports and 60 percent of world trade in the commodity. Maize, moreover, moved to net imports of 1.443 million tonnes in 2010 and rose to 27.13 million tonnes in 2023, an increase of 18.8 times in fourteen years. Counting all imported grain, China's grain self-sufficiency rate has fallen below 80 percent. In recent years, global trade protectionism has been rising and grain supply chains have faced severe challenges, with the risks especially acute for those grain varieties on which China depends heavily on imports. The United States and other countries have frequently imposed additional tariffs on Chinese exports, with a certain negative effect on China's food security. Compared with reliance on imports, grain conservation and loss reduction, as "invisible farmland," can respond more efficiently to the pressure of stabilizing output and guaranteeing supply and to the risk of international "decoupling and broken chains" [5].

1.3 Grain Conservation and Loss Reduction as an Intrinsic Requirement of China's Green Agricultural Development

General Secretary Xi Jinping has pointed out that "food conservation and loss reduction can effectively relieve the pressure on supply and also reduce resource use—a matter of great benefit" [9]. Grain loss reduction has a strong environmental effect [10]. Global grain loss and waste consume 4 percent of the water, 31 percent of the cultivated land, and 23 percent of the fertilizer used in grain production. Converted into carbon emissions, grain loss and waste would exceed 3 billion tonnes, so grain conservation and loss reduction has considerable carbon sink potential. At present, China's multiple cropping index is as high as 130 percent, cultivated land has long been used heavily and nourished lightly, the load is excessive, and the

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quality of cultivated land is generally declining; the black soil is showing a trend of functional degradation, declining quantity, and falling quality. China is a country short of water and one of the 13 water-poor countries in the world. Per capita water resources amount to only 2,300 cubic metres, about one quarter of the global per capita level; annual rainfall is below 400 millimetres on 50 percent of the national territory; agriculture is short of 30 billion cubic metres of water each year; water resources per hectare of cultivated land are about one half of the world average; and groundwater in the North China Plain is severely over-exploited, forming the largest "hollow funnel" area in the world. China's agricultural non-point source pollution is prominent, and per-mu application of chemical fertilizer and pesticide is far above the world average, further aggravating soil and water pollution. Per capita cultivated land is only 1.36 mu, and the average cultivated land operated per household is only 1/400 of that in the United States and 1/40 of that in the European Union. The Third National Land Survey shows that China has 1.918 billion mu of cultivated land, 113 million mu less than ten years earlier. Today, China's grain loss and waste means that more resource factors are consumed and more greenhouse gases are released. It is estimated that greenhouse gas emissions from the food system account for 21 to 37 percent of global greenhouse gas emissions, making it an important lever for achieving the "dual carbon" goals. Reducing grain loss and waste therefore helps cut resource consumption and greenhouse gas emissions, supports the "dual carbon" goals, and advances a path of sustainable development that is resource-conserving, environmentally friendly, and ecologically circular.

1.4 Grain Conservation and Loss Reduction as an Inevitable Choice for Transforming and Upgrading the Food System

On the basis of consecutive bumper harvests and fruitful outcomes of the scientific and technological revolution, China's food consumption structure has changed markedly, the food structure of urban and rural residents has steadily improved, food consumption has been upgraded and its quality raised, consumption of animal protein foods has grown day by day, demand for feed grain has risen rapidly, and residents' food consumption has shifted from "eating enough" to "eating well" and "eating healthily." In addition, urbanization is changing the population structure and thereby driving continued growth in grain demand. For every 1 percentage point increase in the urbanization rate, national grain demand increases by 10 billion jin. China's urbanization rate is expected to reach 70 percent by 2030, by which time more than 100 million people will have moved from rural areas to cities, causing a significant increase in grain demand [11]. As China's urbanization rate rises and incomes grow, food consumption by urban and rural residents will maintain rigid growth, the future food consumption structure will be richer, demand for foods other than traditional staple grains will continue to grow, and demand for feed grain will keep rising. Grain conservation and loss reduction can effectively meet future consumer demand for grain among urban and rural residents and is an important measure for transforming and upgrading China's food system.

1.5 Grain Conservation and Loss Reduction as an Inherent Requirement for Safeguarding Reasonable Returns to Grain Farmers

Safeguarding reasonable returns to grain farmers is an important dimension of safeguarding national food security. At present, farmers' enthusiasm for growing grain is generally low, and phenomena such as abandonment of cultivation and letting land lie fallow occur from time to time. The main reasons lie in two aspects: continuously declining returns and steadily rising opportunity costs. On the one hand, farmers' returns from growing grain have continued to decline. Since 2004, average net profit per mu of grain has trended downward overall, and the three major staple grains—wheat, maize, and rice—have shown net losses for many years. Rapidly rising labour and land costs are the main cause of higher grain production costs. From 2004 to 2023, the average selling price per kilogram of the three major staple grains rose only from 1.41 yuan to 2.67 yuan. In cost terms over the same period, average material and service costs, labour costs, and land costs per mu of the three major staple grains rose by 374.39 yuan, 266.99 yuan, and 248.09 yuan respectively, with average annual growth rates of 5.71 percent, 5.74 percent, and 9.48 percent. On the other hand, farmers' opportunity costs of growing grain have continued to climb. Driven by market, policy, and technological factors, rural industries have entered a fast lane of development, farmers' earnings from off-farm work have risen markedly, the degree of part-time farming has gradually increased, and farmers' inclination to "leave agriculture" and "turn away from agriculture" has become more and more evident. From 1998 to 2023, the share of operating income in rural residents' income fell from 67.85 percent to 34.63 percent, while the share of wage income rose from 26.30 percent to 41.97 percent; wage income has replaced operating income as the main source of farm household income. Calculated from the data in the *National Compilation of Cost and Benefit Data for Agricultural Products* and assuming 28 working days per month, the return per mu in 2008 was equivalent to 3.89 days' wages from off-farm work, but by 2022 it had fallen to 1.14 days, so the opportunity cost of growing grain has risen rapidly. Grain conservation and loss reduction can raise farmers' returns by increasing effective grain output and thereby strengthen their enthusiasm for growing grain.

2. Progress in Strengthening the Long-Term Mechanism for Grain and Food Conservation

Since the 18th National Congress of the Communist Party of China, governments at all levels and relevant departments have thoroughly implemented the spirit of General Secretary Xi Jinping's important instructions and comments,

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incorporated grain conservation and loss reduction into the key tasks of safeguarding food security, and preliminarily established a long-term mechanism for grain conservation and loss reduction that is guided by government, implemented by enterprises, and joined by society as a whole.

2.1 An Increasingly Complete Institutional Framework for Grain Conservation and Loss Reduction

To advance the institutionalization of grain conservation and loss reduction, the relevant Chinese bodies have issued a number of laws and regulations, policy documents, development plans, and industry standards, providing solid support for building institutions and monitoring and standards systems for grain conservation and loss reduction. At the level of top-level design, on 29 April 2021 the 28th session of the Standing Committee of the 13th National People's Congress adopted the *Food Waste Law of the People's Republic of China*, marking the point at which practising strict economy and opposing waste ceased to be a moral appeal and became an explicit legal requirement. In October 2021 the General Offices of the Central Committee of the Communist Party of China and of the State Council issued the *Action Plan for Grain Conservation*, which focuses on the loss and waste problems at the stages of grain production, storage, transport, processing, and consumption and sets out targeted measures for grain conservation and loss reduction. In December 2023 the 7th session of the Standing Committee of the National People's Congress adopted the *Food Security Law of the People's Republic of China*, which explicitly requires that grain conservation work be done well at the stages of grain production, storage, circulation, processing, and consumption. In November 2024 the General Offices of the Central Committee of the Communist Party of China and of the State Council issued the *Action Plan for Grain Conservation and Combating Food Waste*, focusing on grain conservation and loss reduction, raising awareness of grain conservation, and combating waste in the catering industry, and setting out comprehensive and systematic arrangements for grain conservation and loss reduction and for curbing food waste in China.

At the level of technical standards, the National Food and Strategic Reserves Administration has successively organized the revision of 47 standards and specifications for grain conservation and loss reduction, basically completing a standards system covering grain harvest, storage, transport, and other stages. It has issued 23 national and industry standards, including *Wheat Flour*, *Rapeseed Oil*, *Wheat Bran*, and *Germinated Brown Rice*, and organized the formulation and revision of 36 standards related to grain conservation and loss reduction, including the *Technical Specification for Moderate Processing of Rice* and the *Standard for Construction of High-Standard Grain Silos*, providing clearer rules and guidance for grain conservation and loss reduction. Industry standards for the storage and transport stages, such as the *Operating Procedures for Loading and Unloading Bulk Grain Containers* and the *Technical Regulations for Carbon Dioxide Controlled-Atmosphere Grain Storage*, have been formulated to standardize operating procedures and technical points. The first batch of 59 grain reserve enterprises has launched pilot work on standards for green grain storage, effectively promoting moderate grain processing and comprehensive resource utilization.

2.2 New Progress in Technology-Empowered Grain Conservation and Loss Reduction

China has thoroughly implemented the strategy of "invigorating grain through science and technology," and research and development of new technologies, new processes, and new equipment for grain conservation and loss reduction at every link of the grain chain has continued to make breakthroughs. In recent years, China has thoroughly implemented the action to upgrade green grain storage, accelerated the construction of green grain depots, promoted the integrated application of advanced storage technologies such as low-temperature and controlled-atmosphere storage, and driven the modernization of storage facilities through scientific and technological innovation. The coverage of technology-based grain storage in central grain reserves has reached 98 percent, the proportion fit for storage has stabilized above 95 percent, and losses within a single storage cycle have been successfully held below 1 percent; every 1 percentage point reduction in the storage loss rate saves about 300,000 tonnes of grain a year. Experience has been accumulated in the large-scale application of low-temperature grain storage technology, scientific and technological innovation has continued in areas such as insulating materials, automatic control processes, and air circulation devices, intelligent inventory monitoring technology and the "smart sky-eye" system have been developed, and a real-time monitoring and early-warning mechanism for reserve grain has been built, with the system achieving an average effective operating rate of 87 percent. Moderate-processing technologies for loss reduction have been actively promoted, research has been laid out on moderate processing technologies such as flexible rice milling, comprehensive utilization of by-products such as soybean meal, rice bran, rice protein, and soy protein has been actively explored, and the development and application of new technologies such as bio-based materials has been promoted. The Sinograin system has widely promoted green grain storage technologies such as intelligent ventilation, internal circulation temperature control, air-conditioning temperature control, and intelligent controlled-atmosphere storage, bringing the coverage of technology applications centred on green grain storage to 98 percent. Through the application of new technologies and the standardization of grain storage management, the comprehensive loss rate within the storage cycle of large state-owned grain storage enterprises has fallen below 1 percent, energy consumption for storage has dropped by more than 20 percent, and the use of chemical agents has fallen by more than 50 percent.

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2.3 Further Improvement of Infrastructure for Grain Conservation and Loss Reduction

China has continued to standardize storage management, significantly improving the condition of storage facilities and effectively raising the level of applied storage technology. Infrastructure for grain conservation and loss reduction has produced notable results, and the natural loss rate of reserve grain depots within the storage cycle has been held below 0.2 percent. In recent years, departments at all levels have implemented the Quality Grain Project and improved the post-harvest grain service system, building more than 5,500 post-harvest grain service centres in 26 provinces (autonomous regions and municipalities directly under the Central Government) and the Xinjiang Production and Construction Corps, basically achieving full coverage of post-harvest grain services in major grain-producing counties nationwide, with daily drying capacity at these centres reaching 1.11 million tonnes. A special action on scientific grain storage by farm households has been carried out, and 10 million sets of scientific grain storage equipment have been provided to farm households in total, covering small storage tools for households of 0.5 to 2 tonnes, household grain silos of 10 tonnes, and small and medium-sized rural drying equipment of 10 to 20 tonnes, with the average storage loss rate reduced from 8 percent to below 2 percent. Nationwide, low-temperature and near-low-temperature grain storage capacity has reached 200 million tonnes, and storage capacity using controlled-atmosphere technology has reached 55 million tonnes. State-owned grain reserve depots have widely adopted the "four-in-one" new technology of grain cooling, mechanical ventilation, grain condition monitoring, and circulation fumigation; China's grain storage technology has risen to the front rank of the world overall; and the comprehensive loss rate within the storage cycle of state-owned grain depots has been held below 1 percent. The modern grain logistics system has been strengthened, with widespread adoption of bulk loading, unloading, storage, and transport—the "four bulks"—and integrated application of dedicated grain railway wagons and bulk grain trucks, rail-water intermodal loading and unloading technology, containerized bulk grain logistics equipment and hydraulic unloading devices; train unloading platforms, grain receiving systems, and automatic weighing systems have been built, grain loss in the transport stage has been significantly reduced, and the grain transport loss rate has been held below 3 per mille.

2.4 Deepening Public Awareness Campaigns on Grain Conservation and Loss Reduction

In recent years, departments at all levels have carried out in-depth public awareness campaigns on grain conservation and loss reduction with notable results. First, publicity and promotion activities have continued to advance. In conjunction with thematic events such as World Food Day, National Food Security Awareness Week, and National Grain Science and Technology Week, the role of food security education bases has been brought fully into play, and grain and oil science popularization activities have been actively carried out in villages, communities, households, and schools, conveying the ideas of cherishing grain, saving grain, and consuming reasonably and striving to create a social atmosphere in which "saving grain is honourable and wasting grain is shameful." At present, 149 institutions nationwide have been recognized as national-level food security education bases. Second, moderate grain processing has been actively advocated. Grain processing enterprises have been encouraged to adopt the concept of moderate and rational processing, research and application of moderate processing technologies have been encouraged, and the potential for comprehensive utilization of by-products such as bran, rice bran, and soybean meal has been actively developed. Taking rice processing as an example, applying and promoting flexible rice milling technology has raised the rice milling yield by 5 to 8 percentage points compared with traditional technology. Third, catering enterprises have been urged to curb catering waste. Market regulators have encouraged and urged online food-ordering platforms such as Meituan and Ele.me, and their operators, to offer takeaway options such as single-person and multi-person meals, advocating rational and green consumption and curbing catering waste.

3. Difficulties in Strengthening the Long-Term Mechanism for Grain and Food Conservation

In recent years, although China has achieved notable results in grain conservation and loss reduction, loss and waste still exist across the whole grain industrial chain.

3.1 Low Enthusiasm among Farmers and Persistently High Post-Harvest Losses

At present, China has more than 200 million agricultural operators, of which smallholders account for about 98 percent and about 70 percent of the cultivated land area. Although the proportion of farm households storing grain has declined in recent years, it remains relatively high, at about 40 to 50 percent of total grain output. Smallholders thus remain the main body that grows and stores grain. Yet smallholders' enthusiasm for participating in grain conservation and loss reduction is not high, mainly for three reasons. First, as labour costs rise, the opportunity cost for farmers of participating in grain conservation and loss reduction gradually increases, so farmers do less gleaning, which to some extent aggravates post-harvest grain loss. In addition, during mechanical harvesting farmers often do not supervise the machinery service, lacking effective oversight of the operator's work quality, which also leads to grain loss. Second, upgrading storage facilities is costly and yields low returns for farmers. Returns from growing grain are low, and farmers face multiple pressures including high production costs and large market price fluctuations, leaving them little incentive to invest continuously in agriculture or to renew

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technology. Upgrading storage facilities, however, requires certain funding and technical support, and farmers' understanding of modern storage technology and management methods is limited, so their willingness to invest is low. Although China has established a number of post-harvest grain service centres, most farm households find the related costs hard to bear. Third, farmers mostly rely on experience to store grain. Farmers' awareness of scientific grain storage is weak and they rely mainly on experience and habit, using traditional methods such as "grain heaped directly on the ground." For example, about 50 percent of farm households in Heilongjiang still store grain in the traditional way of heaping it directly on the ground, and the volume stored this way once exceeded 10 million tonnes. Under traditional farm storage methods, rodent damage, mould, and insect pests are the main sources of loss, accounting for 49 percent, 30 percent, and 21 percent respectively of farm storage losses.

3.2 Non-Standard Scientific Storage and Transport by Operators, with Relatively Large Losses in the Storage and Transport Stages

At present, waste in China's grain storage stage is relatively serious. The grain loss rate in state grain depots is about 2 percent, on a par with developed countries, but the storage loss rates of other operators are generally high, and losses in the storage stage alone amount to 28 to 35 million tonnes a year. China loses about 120,000 tonnes of grain a year in railway transport, about 25,000 tonnes in river and sea transport, and about 400,000 tonnes in road transport. The main causes lie in three aspects. First, the layout of grain storage institutions is unreasonable. China has established more than 5,500 post-harvest grain service centres, but their uneven regional distribution is particularly evident: about 68 percent of sample villages or townships do not yet have one nearby. Some regions face limited storage capacity and unreasonable regional layout, and local post-harvest grain service centres lag in construction, with their layout and number unable to meet actual service demand, resulting in low grain outbound efficiency and increased risk of grain deterioration [12]. Second, the facilities of social grain storage institutions do not meet standards. Compared with large and medium-sized grain storage enterprises, social grain storage operators such as small and medium-sized enterprises, cooperatives, and farm households generally lack drying capacity, have rudimentary storage facilities, ageing storage equipment, insufficient storage technology, and imperfect ventilation and temperature control systems, resulting in relatively serious grain loss. Third, grain circulation facilities are non-standard. Grain transport methods vary widely from place to place, and non-specialized transport tools and packaging materials are widely used, so grain is easily lost or spilled in transit, with the resulting loss rate exceeding international standards.

3.3 Misaligned Processing Orientation of Enterprises and Over-Pursuit of Refinement in Consumer Demand

Owing to over-processing, the loss rate in China's wheat processing stage reaches 4 to 5 percent, causing more than 6.5 million tonnes of food grain loss every year. At the same time, the by-products of wheat processing—germ and bran—are not effectively developed and utilized, causing a waste of resources and a loss of nutrition. If the extraction rates of wheat and rice were each raised by 3 percentage points, output of wheat flour and rice would increase by about 9.9 million tonnes, equivalent to meeting the annual grain demand of about 55 million people. At present, the reasons for over-refinement in grain processing lie mainly in two aspects. On the one hand, the consumption orientation towards over-refinement is difficult to reverse. As living standards of urban and rural residents continue to rise, consumers often fall into the consumption misconception of favouring "refined rice and fine flour." In recent years, refined rice has accounted for more than 90 percent of the rice supplied on the Chinese market, and special grade 1 and special grade 2 flour (fine flour) together account for more than 70 percent of flour [13]. To better meet consumers' demands for the appearance and taste of grain, grain processing enterprises generally carry out fine processing. Although some enterprises have tried to change this situation, their attempts often end in failure because the appearance and taste of rice and flour exert too great an influence on market competitiveness. On the other hand, the production technology of small and micro grain processing enterprises is not advanced enough. At present, some small and micro grain processing enterprises lack advanced processing equipment and technology and find it difficult to precisely control key parameters such as temperature and milling intensity during processing, resulting in the waste of large quantities of by-products such as rice bran, rice husk, broken rice, and wheat bran.

3.4 Weak Conservation Awareness among Consumers and an Extravagant and Wasteful Culture Not Yet Fully Reversed

The *China Food and Nutrition Development Report 2023*, issued by the Institute of Food and Nutrition Development of the Ministry of Agriculture and Rural Affairs, shows that China's food loss and waste rate is about 22.7 percent. The reasons are mainly reflected in two aspects. On the one hand, some consumers are not strongly aware of cherishing grain. Consumers have limited understanding of grain loss and waste, which leaves them lacking the initiative to conserve grain. Moreover, for lack of conservation awareness, farmers' problem of wasting grain is relatively prominent, with the share of grain wasted by farm households reaching 5.2 percent, of which staple food waste is especially serious, accounting for about 50 percent of total food waste [14]. On the other hand, comparison and display among some consumers occur from time to time. Long-standing consumption concepts such as showing off wealth and seeking to keep up appearances, combined with a lack of awareness of grain conservation and loss reduction, mean that excessive waste is common among consumers in catering

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consumption.

4. Strategic Priorities and Policy Recommendations for Strengthening the Long-Term Mechanism for Grain and Food Conservation

In the new era, grain conservation and loss reduction still have a long way to go. It is necessary to accurately grasp the strategic priorities for building a long-term mechanism for grain conservation and loss reduction at present and for a period to come, to adopt targeted measures, and to persevere over the long term, so as to advance grain conservation and loss reduction steadily and far and provide strong support for safeguarding national food security.

4.1 Strategic Priorities for Strengthening the Long-Term Mechanism for Grain and Food Conservation

At present, post-harvest grain loss and waste still exist in China, and in the links of grain production, reserve, and consumption many problems remain, including low enthusiasm for grain conservation and loss reduction, non-standard grain storage and transport, insufficient awareness of preventing waste, and a low level of scientific grain storage. The strategic focus should therefore be placed on the difficult problems in building the long-term mechanism for grain and food conservation at present, so as to make new progress in grain and food conservation.

4.1.1 Continuing to Focus on Grain Conservation and Loss Reduction across the Whole Industrial Chain at the Production End

In response to low farmer enthusiasm for grain conservation and loss reduction and the need to improve the quality of agricultural technical services, farmers should be guided towards careful harvesting, efficient and low-loss agricultural machinery should be promoted, and machinery operators' standard operating capacity should be raised. In response to the current problem of non-standard grain storage and transport, work should start from scientific grain storage, green grain storage, and smart grain storage; the problem of grain heaped directly on the ground should be resolved step by step; the construction of high-standard grain silos should be encouraged; and the building of smart grain depots should be strengthened. Supporting facilities for grain transport should be built, multimodal grain transport should be developed, and a complete bulk grain transport service network should be established to effectively reduce grain loss in transit. In response to the reduced extraction rates and lost nutrients caused by over-processing, grain should be guided towards moderate processing, standardization of moderate grain and oil processing should be advanced, the reduction and substitution of feed grain should be deepened, and the whole-grain industry should be developed [15].

4.1.2 Deepening the Prevention of Waste across Society at the Consumption End

In response to serious consumer food waste, an action to raise the whole population's awareness of grain conservation should be carried out at the household and social levels. At the household level, nutritionally balanced and healthy eating habits should be advocated, households should be guided to buy and store ingredients according to need, outdated customs should be changed, households should be encouraged to cherish and save grain, the good family tradition of diligence and thrift should be promoted, and food waste should be prevented [16]. At the social level, grain conservation and combating food waste should be incorporated into citizens' covenants, village rules and conventions, and industry norms, and into the building of civilized cities, civilized villages and towns, civilized work units, civilized families, and civilized campuses, and special educational activities against food waste should be carried out.

4.1.3 Actively Strengthening All-Round Policy Support at the Government End

To further improve the quality and efficiency of grain conservation and work against food waste, action should be taken in areas including production standards, punishment of violations, industry self-discipline, statistical surveys, organizational assessment, publicity and promotion, and international cooperation. Technical specifications for loss reduction in mechanized harvesting of rice, maize, wheat, and soybeans and quality standards for mechanized harvesting operations should be formulated; indicators such as grain processing precision should be reasonably determined; illegal acts in the fight against food waste should be corrected and prosecuted; food and catering industry associations should be supported in issuing anti-waste initiatives; anti-waste actions should be actively carried out in canteens of government bodies, schools, and enterprises; a complete statistical and survey system should be established, with special data collection and analysis carried out for different fields; requirements for grain conservation and combating food waste should be highlighted in assessments such as those for food security and comprehensive rural revitalization; publicity activities on cherishing grain and opposing waste should be carried out; and multilateral international cooperation and exchange on grain conservation and loss reduction should be encouraged and supported, so as to provide all-round institutional support for grain conservation and work against food waste [17].

4.2 Policy Recommendations for Strengthening the Long-Term Mechanism for Grain and Food Conservation

China's grain loss and waste run through the links of production, transport, storage, processing, and consumption. Measures should be tailored to local conditions and targeted, and advanced step by step with clear priorities, so as to achieve new results in grain conservation and loss reduction and in preventing waste.

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4.2.1 Solidly Carrying Out Grain Conservation and Loss Reduction across the Whole Industrial Chain

First, promote grain conservation and loss reduction in grain production. Precision agriculture technology should be promoted more vigorously, and losses in grain production reduced through techniques such as precision fertilization, irrigation, and pest and disease control. Efficient, low-loss modern agricultural machinery should be popularized through fiscal subsidies, tax incentives, and other means to raise grain harvest efficiency. Second, improve grain storage infrastructure. Farmers and agricultural enterprises should be guided to replace obsolete storage facilities and to build modern storage facilities that adapt to climate change and have functions such as moisture and pest resistance, so as to reduce grain storage losses. The introduction of technologies such as the Internet of Things, big data, and artificial intelligence should be encouraged to monitor storage facilities in real time, realize automatic adjustment of temperature and humidity, and prevent grain loss caused by improper storage conditions. Third, optimize the grain logistics service network. The construction of the grain transport network should be strengthened, especially by upgrading road, rail, and other grain logistics infrastructure in rural and remote areas; green grain packaging materials and energy-saving, environmentally friendly transport methods should be promoted; and a national grain circulation information platform should be established to achieve full traceability of grain from production to consumption [18]. Fourth, promote moderate grain processing. Grain processing enterprises should be encouraged to introduce moderate processing equipment and technology, the development of efficient and low-loss grain processing technology should be supported, and grain processing enterprises should be supported and encouraged to convert by-products generated during production, such as rice bran, wheat bran, and maize germ, so as to effectively reduce losses in grain processing.

4.2.2 Comprehensively Carrying Out Work to Curb Catering Waste

First, strengthen the management and guidance of the catering industry. Waste control standards for the catering industry should be issued, clarifying the grain conservation and loss reduction requirements for catering operators at the stages of production, processing, and service. Grain conservation training in the catering industry should be strengthened, catering enterprises should be regularly organized to take part in training on grain conservation and loss reduction technology and management, and the conservation awareness and professional capacity of catering practitioners should be enhanced. Second, promote refined services by catering enterprises. Catering enterprises should be encouraged to offer diverse dish options such as "small portions" and "half portions" to meet consumers' individual needs. Through policy guidance and publicity, catering enterprises should be encouraged to offer "takeaway packaging" services to avoid food waste. Third, encourage the application of innovative technologies in the catering industry. Catering enterprises should be supported in introducing advanced ingredient management and inventory control technology and in applying intelligent systems for ordering and allocation management, so as to make ingredient procurement and storage more scientific and avoid waste caused by expiry or spoilage. Fourth, strengthen social mobilization and public education [19]. Public education on grain conservation and loss reduction should be carried out through multiple channels including media, the internet, and communities; social publicity should be intensified; public welfare activities such as the "Clean Plate Campaign" should be advocated; and food conservation education for the whole population should be carried out, creating a good atmosphere in which society as a whole consciously conserves grain.

4.2.3 Establishing and Improving a Policy System for Food Conservation

First, improve incentive mechanisms and support measures for grain conservation. A food conservation performance evaluation system with work units as the main body should be established, and their grain conservation and loss reduction results assessed regularly. Work units that perform outstandingly in food conservation should be commended and rewarded through government subsidies, policy support, and other means. Second, improve supervision and management mechanisms for food waste. Through big data, the Internet of Things, and other means, a nationwide food waste monitoring system should be established to regularly assess the food waste situation in different regions, industries, and enterprises. Industry associations should be encouraged and supported in formulating self-discipline norms, prompting the catering and food processing industries to establish self-inspection mechanisms and to review and publicly report food waste regularly. Third, intensify supervision and policy enforcement. Supervision of waste in the catering industry should be intensified, especially supervision and inspection of food waste in catering enterprises' food procurement and inventory management; clear reward and penalty policies for catering waste should be issued; and catering enterprises and individuals that perform outstandingly in grain conservation and loss reduction should be rewarded. Fourth, carry out cross-departmental collaboration and international cooperation. Cross-departmental collaboration mechanisms among agriculture, commerce, environmental protection, education, and other relevant departments should be promoted to form a synergy in food conservation policy. Drawing on mature international experience in grain conservation and loss reduction, China should cooperate with international institutions such as the Food and Agriculture Organization of the United Nations and the World Bank to improve and optimize food conservation institutions and mechanisms.

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