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Enhancing the Efficiency of Pig Production by Utilizing Advanced Breeding Techniques

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Abstract. Since the farming society, people have begun to cultivate land and raise animals at the same time to provide a stable source of food. As one of the earliest animals raised by humans on a large scale, pigs are still the most purchased meat per capita today, occupying a large part of animal husbandry system. In modern animal husbandry, pig breeding is of utmost importance, as it relates to pork production and quality, as well as the economic benefits of the livestock industry. Selection, genetic marker technology and gene editing techniques assist in pig breeding, such as removing key genes that contribute to the pathogenicity of PRRS viruses. In this paper, after analyzing the stress resistance of different pig breeds, it was found that local pig breeds have potential advantages in disease-resistant breeding research. Crossing them with introduced pig breeds can improve production performance and economic benefits. These research achievements not only provide a scientific basis for pig breeding but also offer new directions for the genetic improvement of global pig breeds and the development of new breeds, thus promoting the sustainable development of the animal husbandry industry.

Keywords: Pig, Breeding, Crossing, animal husbandry.

1. Introduction

The significance of animal husbandry to national development is enormous. Today, as people's living environments continue to improve gradually, meat accounts for an increasing proportion of the food consumption structure. Among the numerous meat products, pork is one of the most popular meats among people[1]. According to research predictions, pork will continue to serve as the primary meat consumed by both urban and rural residents in the foreseeable future[2]. Pork is favored because it maintains good meat quality while producing significantly higher yields than other livestock, making its price more competitive compared to other livestock. Therefore, how to surpass the current production performance has become an important research topic in the development of animal husbandry.

After the improvement in consumption level, people pay more attention to the quality of pork, such as carcass commercial value, meat sensory, nutrition, technical characteristics, convenience and social image[3]. When the quality of pork has been improved to the average level, the production performance of pigs becomes the key factor for the development of animal husbandry, which covers various aspects such as reproductive performance, growth traits, and meat quality[4]. There are many factors that affect the production performance of pigs, such as genetic factors, environmental factors, nutritional factors and diseases. Among them, genetic factors are the most important part that affects the production performance of pigs. Only by selecting high-quality breeds can we maximize the economic performance of pigs. At present, the known pig breeds in the world have basically been discovered, so to obtain new excellent breeds, breeding is generally required.

Globally, significant progress has been made in pig breeding research. Scientists have been dedicated to studying pig genetics in order to improve their growth rate, disease resistance, and meat quality. Advanced technologies can be used to genetically provide pigs with stronger disease-resistance capabilities. Moreover, research has shown that local pig breeds naturally have stronger disease resistance. This can be utilized through hybridization to improve the production performance of commercial pig herds.

This paper discusses the role of genetic breeding technology in actual pig production and the current status of pig breeding, and comparatively analyzes the genetic characteristics of local and imported pig breeds. Maximizing the genetic advantages of local breeds and combining them with those of imported breeds to produce healthier and more disease-resistant herds is an issue worth considering. At the same time, breeding programs must also consider ethical impacts and animal welfare. In pig breeding, animal welfare not only affects their health and production performance, but is also a reflection of the current level of animal welfare in the animal husbandry industry[5]. It is crucial to ensure that breeding practices are humane and do not compromise animal welfare. Continuous innovation in breeding work is essential for the development of new breeds with higher economic value and stronger production performance. B By focusing on the above issues, this paper hopes to contribute to the sustainable development of animal husbandry and create greater economic benefits.

2. The Role of Breeding in Pig Production

2.1. The Development and Challenges of Pig Breeding Technology

Scientists have long been dedicated to the study of animal breeding. With the passage of time and technological advances, animal breeding techniques and methods have become increasingly advanced, been improved, from just blindly pursuing meat production in the beginning to pursuing meat production and quality today. One of the major advances in pig breeding was the realization of a weight gain of 800 g per day and a lean meat percentage of over 60%, which marks the true emergence of lean pigs. As more and more pig breeds are cultivated, pig breeding in developed countries has shifted from variety selection to specialized complementary breeding[6]. Along with the acquisition of different superior breeds through selection, there are many challenges, the most serious of which is disease. For pigs, as a concentrated livestock, sudden outbreaks of infectious diseases can cause fatal harm to the entire herd, posing a significant threat to the economics of the breeding industry.

Porcine Reproductive and Respiratory Syndrome, which spreads widely among pigs, is particularly concerning due to its airborne transmission and highly contagious nature. Many pig breeds with insufficient disease resistance, once infected with PRRS, can cause severe losses to pig farms. Therefore, farms typically implement regular monitoring, strengthen feeding management, and vaccinate pigs to prevent the spread of the disease[7]. However, with the advancement of technology, it is now possible to knock out key genes involved in the pathogenesis of PRRS through genetic markers, thereby creating resistance to the disease. This resistance can then be stably inherited by the next generation through breeding techniques[8]. For major infectious diseases that endanger the whole world, such as Infection with African swine fever virus, major breeding companies generally choose genome selection technology, which can not only effectively prevent ASF, but also eliminate genetically inferior pigs in advance through genome selection, reduce the number of breeding pigs and the risk of epidemic spread, and improving the breeding level[9].

A recent study measured Huainan pig, Duroc pig, Landrace pig and Large White pig to analyze the stress resistance of different pig breeds. It was found that compared with common pig breeds, the Huainan pig had stronger stress resistance and was more suitable for use in disease-resistant breeding research[10]. As same as the research on Large White and Landrace pigs, the Jilin spotted pigs showed significantly higher body length, chest circumference, and backfat thickness than Large White and Landrace pigs, and their meat quality was also better. However, the local pig breeds in China have always had problems such as slow growth, low lean meat rate, and poor litter performance[11].

2.2. The Application and Progress of Pig Breeding Technology

Through these studies, it has been found that the widely bred pig breeds such as duroc in the world are actually inferior in meat quality to the local breeds with smaller breeding numbers. Therefore, the reasons for breeding them are their superior growth performance, adaptability, and strong

reproductive ability. In addition to these production-related reasons, another important point is that these pig breeds have obvious hybrid advantages. When used as paternal lines in hybridization, they can produce offspring with excellent quality. Binary and ternary hybridization of locally bred pigs with imported Western pig breeds can significantly improve production performance and economic benefits[12].The major issues that persist in local pig breeds are slow growth, low lean meat percentage, and poor reproduction performance. These are also the primary areas for improvement in current research on local pig breeds. Achieving the desired high-quality breeds solely through interbreed selection takes too long, therefore, breeding hybridization has become the preferred choice.

There is a significant genetic difference between local pigs and exotic pigs in China, so when they are hybridized, a greater hybrid vigor and genetic complementation effect can be generated, resulting in higher-quality offspring. The Suzhi black pig is a high-quality black pig bred from the crossbreeding of the Huanghuaihai black pig and an exotic pig. Based on the current breeding of Suzhi black pig, some studies have introduced the bloodline of Berkshire pig, and it has been found through experiments that the first litter birth weight of Suzhi black pig after crossing has been significantly improved, and it also has a good effect on the growth rate, body shape and other aspects[13].

Domestic local pig breeds have high fertility, excellent meat quality, and strong stress resistance. Although they have so many advantages that we need, from a comprehensive perspective, it is undoubtedly that breeds such as Duroc, Landrace, and Large White Pigs can bring higher economic value. Therefore, when choosing pig breeds for breeding, a comprehensive analysis should be conducted to obtain the most suitable breed after a comprehensive evaluation. With the advancement of breeding technology, breeding farms rarely breed introduced breeds alone. They always choose to crossbreed them with each other or with local pig breeds and breed the hybrid pig breeds that possess the advantageous traits from both parents.

A question to ponder, then, is how to integrate the strengths of local pig breeds and then introduce them to evolve them into a new, superior breed. An effective way is the need for continuous selective breeding. A representative example of this is the Suhuai pig. The Suhuai pig is a brand-new pig breed selectively bred through crossbreeding the Xinhuai pig and the Large Yorkshire pig. The Xinhuai pig is an excellent local breed that was cultivated earlier. However, with the development of the commodity economy and the diversification of market demands, the Xinhuai pig can no longer fully meet these needs, necessitating further improvement through breeding and selection. So the Suhuai pig was bred. While retaining its own strengths, it addressed the Xinhuai pig's issues of slow growth, low lean meat percentage, and low litter size. But during the selective breeding process, due to the prominent heterosis in the first filial generation, the number of live piglets per litter, teats, and birth weight were all at their highest. But as inbreeding within the same population progressed, these three traits showed varying degrees of decline, this is an area that requires further research and improvement[14].

The Min pig is the only local pig breed in Heilongjiang Province. It used to be one of the major pig breeds in China, It has high fertility, strong resilience, and good meat quality. Using the Min pig, excellent breeds such as the Xinjin pig and the Northeast Flowered pig have also been developed. Recent studies have focused on hybridizing the Min pig as the female parent with the Berkshire pig, Songliao Black pig, Pietrain pig, and Duroc pig as the male parents, and conducting research and analysis on the offspring. It was found that the differences among these four hybrid combinations were not significant in terms of daily weight gain and lean meat percentage, but there were significant differences in meat quality traits and intramuscular fat content. If a farm prioritizes excellent meat quality as the main selection criterion, with growth performance being secondary, then crossing the Berkshire pig or Songliao Black pig with the Min pig would be the ideal combination. However, the optimal combination may vary depending on different requirements. So when selecting hybrid breeds, it is essential to clarify the farming needs, as the offspring from hybridization may be excellent but may not align with the farm's intended positioning, ultimately resulting in economic benefits that fail to meet expectations[15].

The litter performance, including litter size, number of live piglets, litter birth weight and piglet birth weight, is an important indicator of the reproductive performance of sows[16]. Taihu pig is a local breed and also the pig breed with the highest number of offspring recorded in the world. However, aside from its reproductive performance, its slow growth rate, low lean meat percentage of carcass, and low feed conversion rate have resulted in limited use of Taihu pigs in actual production. Research has involved crossing Taihu pigs with Landrace pigs and Large White pigs in different binary hybrids and then crossing the offspring with Duroc boars for analysis. The final results showed no significant difference in average total litter size, average litter size at weaning, and average number of live piglets per litter. However, the issue of slightly decreased reproductive ability in the first filial generation still persisted[17]. Recently, in Spain, people have grown increasingly fond of keeping micropigs as pets. However, many people found out that they didn't like it after keeping them, so they abandoned them. The abandoned micropigs entered the wild and hybridized with local wild boars. Although experiments have shown that the health of the micropig population has not been greatly affected, this will disrupt the local ecological environment, and the offspring of the hybridization is also beyond people's expectations[18]. It can be seen that after breeding, the characteristics of two varieties can be combined to obtain varieties with parental traits. Therefore, it is particularly important to choose the appropriate parents, which also requires a large number of experiments and data to obtain the correct combination. If the selected parents are not suitable, the offspring may be worse. This is also the reason why the successful hybridization examples of local pig breeds cannot be widely applied. Therefore, in actual production, it is still the most reliable to choose suitable economic varieties according to the region.

2.3. Outlook for Breeding Work

To improve the breeding level of pigs, continuous improvement and technological innovation are required. High-quality breeding pigs are selected through methods such as performance measurement, genetic evaluation, and gene selection, and then put into production to create economic value, which in turn can be fed back into the breeding industry to form a virtuous cycle of development. At the same time, people should also actively introduce the world's advanced pig breeding technology, constantly improve breeding levels, and create better breeds [19]. Currently, the main goal of breeding research is to strengthen the breeding and selection process, cultivate more excellent hybrid pig breeds with wider applicability, and create economic value. Moreover, selecting outstanding pig breeds is also a significant contribution to the genetic improvement of pig breeds worldwide, providing new options and directions for crossbreeding other breeds[20]. At the same time, in the process of breeding, people must also pay attention to animal welfare, treat experimental animals well, and ensure that their behavior does not violate human ethics and develop breeding techniques in the right way.

3. Conclusion

In the modern livestock industry, pig breeding is of paramount importance, serving as the key to enhancing pork production and quality. This article describes the successful application of breeding technology, marking a milestone in cultivating lean-type pigs with a daily weight gain of 800 grams and a lean meat percentage exceeding 60%. Since then, the development of breeding has advanced rapidly with scientific progress. By knocking out critical genes responsible for the pathogenicity of the PRRS virus, the disease resistance of pigs has been significantly improved. Additionally, genomic selection technology can be employed to prevent large-scale diseases like African swine fever. This article also underscores the benefits of crossbreeding local breeds, such as Huainan pigs and Min pigs, with exotic breeds. By harnessing the superior traits of both parents, the apparent shortcomings of the native breeds are ameliorated, growth performance is enhanced, greater economic benefits are generated, and the survival ability of offspring is strengthened.

Despite these advancements in animal breeding, this article also points out certain limitations in the breeding process. To maintain the purity of certain breeds, inbreeding is necessary, but this can lead to problems such as reduced litter size and birth weight. Furthermore, ethical and animal welfare

concerns must be addressed in breeding practices, with a commitment to treating animals kindly in experiments. Looking ahead, continuous innovation in breeding work is crucial. By integrating the advantages of current high-tech industries, such as artificial intelligence, we can enhance breeding efficiency and precision. It is also essential to cultivate new breeds that not only have economic value but also exhibit strong disease resistance and adaptability to changing market demands. This approach can promote the sustainable development of the livestock industry, ensuring that the breeds resulting from breeding programs align with production goals and market needs, thereby contributing to the genetic improvement of global pig breeds.

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