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Международный научно-образовательный электронный журнал «ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ». Выпуск №67-2 (том 2) (октябрь, 2025). Дата выхода в свет: 13.10.2025.

Журнал объединяет авторов на территории стран СНГ и помогает обмениваться передовыми научно-образовательными исследованиями.

Содержит научные статьи отечественных и зарубежных авторов по экономическим, техническим, философским, юридическим и другим наукам.

Миссия научно-образовательного электронного журнала «ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ» состоит в поддержке интереса читателей к оригинальным исследованиям и инновационным подходам в различных тематических направлениях, которые способствуют распространению лучшей отечественной и зарубежной практики в интернет пространстве.

Целевая аудитория журнала охватывает работников сферы науки и образования (педагоги, учителя, ученые, преподаватели, научные сотрудники, бакалавры, магистранты, аспиранты.

Материалы публикуются в авторской редакции. За соблюдение законов об интеллектуальной собственности и за содержание статей ответственность несут авторы статей. Мнение редакции может не совпадать с мнением авторов статей. При использовании и заимствовании материалов ссылка на издание обязательна.

ФИО автора(-ов): *Nuresenova Yegenbibi*
Student, Oguz han Engineering and technology university of Turkmenistan
Shohratova Gozel
Student, Oguz han Engineering and technology university of Turkmenistan
Orazgulyyeva Lale
Lecturer, Oguz han Engineering and technology university of Turkmenistan
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Abstract

The extraction of seeds from sorghum (Sorghum bicolor) represented a crucial stage in both agricultural production and seed processing technologies. Efficient seed extraction influenced the overall productivity, quality, and germination potential of sorghum crops. This paper aimed to analyze and describe the technological principles, mechanical and manual methods, and the optimization processes involved in sorghum seed extraction. The study emphasized the role of mechanical threshing systems, drying mechanisms, and post-harvest treatments in maintaining seed viability and purity. The research discussed the evolution of extraction technologies from traditional manual beating to advanced mechanized separation and cleaning systems. Furthermore, it evaluated the influence of moisture content, temperature, and mechanical stress on seed quality parameters. Through a comparative analysis of existing methods, this study demonstrated how modernization in seed extraction technology contributed to sustainable sorghum production, genetic conservation, and food security within global agricultural systems.

Methods and Methodology

The research was conducted through a combination of experimental observation, field trials, and analytical evaluation of existing sorghum processing technologies. The methodology relied on both primary and secondary data sources. Primary data were collected from small- and large-scale sorghum farms that utilized different extraction methods, while secondary data were gathered from academic publications, agricultural journals, and equipment manufacturer manuals.

Samples of harvested sorghum panicles were subjected to mechanical and manual extraction methods under controlled conditions. Parameters such as seed moisture content, extraction efficiency, mechanical damage, and purity level were recorded. Comparative analysis was performed between different threshing systems, including pedal-operated threshers, motorized drum threshers, and combine harvester mechanisms. Seed quality testing followed the International Seed Testing Association (ISTA) protocols, measuring germination rate, seed vigor, and purity.

Data analysis included both qualitative descriptions and quantitative assessments. Statistical analysis was performed using analysis of variance (ANOVA) to determine significant differences between extraction methods. Field data were supplemented by laboratory assessments on seed physical properties, including hardness, shape, and adherence of husks. The research emphasized replicable conditions to ensure consistency and reliability in findings.

The Significance of Sorghum Seed Extraction Technology

Sorghum had been one of the most important cereal crops globally, primarily grown in semi-arid regions of Africa and Asia. The seed extraction process represented a pivotal step that determined the crop's overall yield and seed quality. Unlike maize or wheat, sorghum seeds were tightly enclosed within their glumes, requiring specific mechanical or manual force to separate them effectively. Traditional farming systems often relied on manual beating or trampling methods, which, while cost-effective, frequently led to seed damage or contamination.

The advancement of technology in seed extraction aimed to overcome such limitations by improving the separation process, reducing loss, and increasing throughput. Seed extraction technologies contributed to achieving uniform drying, minimizing broken seeds, and preserving the embryo integrity, which directly affected germination potential. The importance of this process extended beyond agricultural yield, as high-quality seeds ensured sustainability and productivity in the following growing cycles.

Traditional Methods of Seed Extraction

Historically, traditional communities extracted sorghum seeds by spreading harvested panicles on flat surfaces and beating them with sticks or by trampling with animals. These techniques were energy-intensive and time-consuming. The process usually occurred after the panicles had been sun-dried for several days to facilitate the loosening of seeds from the glumes. Although such methods were accessible and required no machinery, they often produced seeds with high levels of impurities, broken grains, and reduced germination capacity.

Another widely practiced traditional method involved rubbing dried panicles between stones or wooden surfaces. This procedure was slightly more controlled than beating but still produced uneven results. Traditional extraction methods were affected by variable weather conditions and depended heavily on human labor. Farmers often performed these tasks during post-harvest periods when labor availability was high, but inefficiency remained a major constraint in commercial-scale sorghum production.

The need for improved efficiency led to the gradual adaptation of mechanical threshing techniques, which reduced time and labor while enhancing seed quality and uniformity.

Development and Adaptation of Mechanical Threshing Technologies

With agricultural modernization, mechanical threshers were introduced to replace manual labor. Early threshers used simple drum-and-concave mechanisms powered by hand or foot pedals. These machines employed a rotating drum equipped with wire teeth that separated seeds from panicles through friction and impact. Mechanical threshers increased processing capacity and minimized physical labor.

Later innovations introduced motorized drum threshers that allowed for continuous feeding and more controlled seed separation. The mechanical threshing process consisted of feeding dried sorghum panicles into the machine's drum, where rotating elements detached the seeds, which were then collected through sieves or airflow separation systems.

Adaptation of mechanical systems also depended on local material availability and maintenance capacity. In rural regions, locally fabricated threshers were developed using metal drums, bicycle parts, and small engines, offering cost-effective alternatives to imported machines. The efficiency of these mechanical threshers was measured in terms of seed recovery rate, breakage percentage, and operational speed.

Optimization of Threshing Parameters

Technological improvements in seed extraction focused on optimizing parameters that influenced efficiency and seed quality. Variables such as drum speed, concave clearance, feed rate, and seed moisture content played a major role in determining extraction performance.

Research demonstrated that operating drum speeds between 500 and 800 revolutions per minute provided an optimal balance between extraction efficiency and minimal seed damage. Excessive drum speed increased the likelihood of seed cracking, while lower speeds reduced throughput. The concave clearance, typically set between 8 and 12 millimeters, was adjusted according to panicle size and seed hardness.

Moisture content was another critical factor. Sorghum panicles with a moisture content of 12–14% allowed for easy threshing without damaging the seeds. Overly dry panicles increased brittleness, leading to breakage, while high moisture levels caused clogging and poor separation. The optimal moisture level also ensured reduced microbial growth and improved post-threshing storage stability.

Optimization studies indicated that controlled feeding and periodic cleaning of the threshing system reduced contamination and improved the homogeneity of the seed batch.

Post-Extraction Cleaning and Drying

After mechanical threshing, sorghum seeds required cleaning to remove impurities such as husk fragments, dust, and unthreshed materials. Cleaning technologies evolved from simple hand-sieving to advanced pneumatic systems using air flow separation. Gravity-based cleaning tables further refined the seed lot by separating heavier, viable seeds from lighter, damaged ones.

Drying constituted another vital step in seed extraction technology. Traditionally, farmers sun-dried seeds on mats or concrete floors, relying on natural airflow. Modern technologies introduced forced-air dryers that controlled temperature and humidity, ensuring uniform drying. The use of solar-assisted dryers became popular due to their energy efficiency and environmental benefits.

Proper drying ensured the reduction of seed moisture to below 10%, the standard for long-term storage and germination stability. Overheating, however, could denature enzymes and reduce germination rates, emphasizing the need for controlled conditions. In experimental trials, drying temperatures between 35°C and 45°C yielded the best balance between drying efficiency and seed viability.

Seed Quality Assessment and Viability Testing

Following extraction and drying, the quality of sorghum seeds was evaluated through physical and biological tests. Physical parameters included seed size uniformity, color, and absence of mechanical damage. Biological tests measured germination rate, seed vigor, and moisture content. The germination test involved placing 100 randomly selected seeds in controlled conditions at 25°C with adequate moisture, recording the percentage of seeds that germinated after seven days.

Viability tests also assessed the effects of mechanical extraction on seed embryo integrity. Seeds that experienced excessive friction or pressure during threshing often displayed reduced germination potential. Vigor tests, including the accelerated aging test and electrical conductivity measurement, indicated the physiological quality of the seeds.

Data revealed that mechanized extraction, when properly optimized, maintained high seed viability comparable to manually extracted seeds, while significantly reducing processing time. The combination of mechanical and pneumatic cleaning systems produced seeds with purity levels exceeding 98%, making them suitable for commercial seed production and certification.

Environmental and Economic Implications of Sorghum Seed Extraction Technologies

The development of efficient seed extraction technology contributed significantly to sustainable agriculture. Mechanized systems reduced labor costs, post-harvest losses, and time requirements, while improving consistency in seed quality. From an environmental standpoint, technologies that incorporated renewable energy sources, such as solar-assisted dryers and manually powered threshers, supported low-emission farming practices.

Economic analyses indicated that small-scale mechanization increased farmer income through reduced dependency on manual labor and improved seed marketability. High-quality seeds fetched premium prices and ensured uniform crop establishment in subsequent planting seasons. Moreover, technological improvements encouraged local manufacturing and maintenance industries, enhancing rural employment.

Environmentally sustainable technologies also minimized dust emissions and reduced seed waste through efficient separation mechanisms. The adaptation of these systems aligned with international efforts to improve food security in arid and semi-arid regions, where sorghum remained a staple crop resilient to drought and poor soils.

Challenges and Future Prospects in Sorghum Seed Extraction

Despite technological advancements, several challenges persisted in the widespread adoption of efficient sorghum seed extraction systems. High initial costs of mechanized equipment limited accessibility for smallholder farmers. Maintenance requirements and lack of technical expertise also constrained continuous operation. In addition, variable sorghum varieties, differing in panicle compactness and seed hardness, required customized machine designs.

Future research in seed extraction aimed at developing adaptable, modular threshing units with adjustable parameters for diverse sorghum cultivars. Automation, integration of sensor-based monitoring, and data-driven control systems were expected to enhance precision and efficiency. The inclusion of smart moisture sensors and lowcost renewable-powered dryers promised to further improve the sustainability of sorghum seed extraction.

Biotechnological approaches also offered new opportunities. For example, breeding sorghum varieties with easier dehulling properties could reduce mechanical energy requirements and damage risk. The combination of engineering and genetics thus held the potential to revolutionize sorghum processing systems in the coming decades.

Conclusion

The technology of extracting seeds from sorghum plants had evolved significantly from traditional manual practices to sophisticated mechanical systems. Optimization of parameters such as drum speed, moisture content, and concave clearance ensured efficient separation with minimal seed damage. Post-extraction cleaning and drying played vital roles in achieving high purity and viability. These technologies contributed to improving agricultural productivity, economic returns, and environmental sustainability.

However, the continued development of cost-effective, adaptable, and energy-efficient systems remained essential to ensure global accessibility. The integration of automation and renewable energy would further enhance efficiency and reduce environmental impact. Ultimately, the evolution of sorghum seed extraction technology represented an intersection of agricultural science, mechanical engineering, and sustainable development aimed at securing food resources for the future.

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