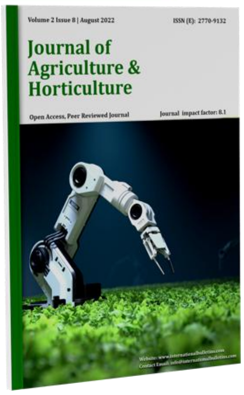

THE STORAGE PROCESS OF MUNG BEAN GRAINS UNDER WAREHOUSE CONDITIONS AND THE FACTORS INFLUENCING THEIR QUALITY

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Abstract. This study investigates the impact of permanent storage conditions on the quality of mung bean (Vigna radiata) grains. Key environmental factors—including temperature, relative humidity, ventilation, and sanitary status—were evaluated for their effects on the physical, biochemical, and technological attributes of the grain. The results demonstrate that maintaining optimal temperature–humidity regimes and ensuring sufficient aeration in permanent storage facilities effectively preserves the nutritional composition, germination ability, and overall visual quality of the grains. In contrast, inadequate storage conditions may lead to excessive heating, increased moisture levels, and infestation by pests and microorganisms, ultimately causing substantial deterioration in grain quality.

Keywords: mung bean, Vigna radiata, grain quality, permanent storage, temperature, relative humidity, ventilation, sanitary conditions, pest infestation, biochemical changes, postharvest preservation.

Introduction

Mung bean (Vigna radiata) is one of the important leguminous crops cultivated in Uzbekistan and is valued as a dietary food product due to its high nutritional content. Its grains contain a rich proportion of protein (24–26%), have a low glycemic index, and are abundant in vitamins and minerals, making the crop significant for national food security. However, because mung bean grain is biologically active, improper storage conditions can intensify respiration, causing grain overheating, moisture accumulation, fungal development, and pest infestation.

Permanent-type storage facilities—constructed mainly from reinforced concrete and equipped with systems for microclimate regulation—are considered suitable structures for long-term preservation of grain quality. Nevertheless, if key environmental factors such as temperature, relative humidity, ventilation, and sanitary conditions are not properly controlled, the quality of the stored product may deteriorate sharply.

The purpose of this study is to scientifically evaluate the effects of permanent storage conditions on the physical, chemical, biochemical, and microbiological parameters of mung bean grain.

Materials and Methods

The research was conducted in permanent-type reinforced concrete storage facilities located in the Tashkent region. For analysis, first-grade mung bean (Vigna radiata) grains with an initial moisture content of 12–13% and a purity level above 98% were selected.

Storage conditions:

- **Temperature:** 10–12°C (optimal), 18–22°C (elevated)
- **Relative humidity:** 60–65% (optimal), 75–80% (high)
- **Ventilation:** natural and forced aeration

• **Storage duration:** 6 months

Parameters evaluated:

1.Physical characteristics: grain color, surface gloss, mechanical damage, grain mass, and bulk density

2.Technological indicators: germination percentage, water absorption capacity, cooking properties

3.Biochemical analyses: moisture, protein and starch content, enzymatic activity

4.Microbiological parameters: presence of mold fungi, bacteria, and storage pests

All analyses were performed in accordance with the national standards of Uzbekistan (O'zDST).

Results

The study compared the effects of two contrasting storage regimes in permanent warehouses: an optimal microclimate and a non-standard condition characterized by elevated temperature and humidity. The findings revealed pronounced differences in the physical, technological, biochemical, and microbiological properties of mung bean grains.

Changes in Physical and Technological Indicators. Physical and technological characteristics of mung bean stored for six months in permanent warehouses are presented in Table 1. Based on the data in Table 1, detailed analysis showed that all varieties experienced gradual declines in grain weight, bulk density, and water absorption capacity over the storage period. These reductions were more pronounced under elevated temperature and humidity conditions.

For example, the initial grain mass of the variety Durdona was 1.82 g, whereas after six months of storage it decreased to 1.75 g, indicating a reduction of 3.8%. A similar trend was observed in Radost, where grain mass decreased from 1.77 g to 1.70 g, and in Turon, where it declined from 1.78 g to 1.72 g. The average reduction across all varieties ranged between 3.5–4.0%.

Changes in bulk density were even more pronounced. In Durdona, bulk density decreased from 770 g/dm^3 to 742 g/dm^3, resulting in a loss of 28 units (3.6%). In Radost, the decline was from 747 to 720 g/dm^3 (27 units or 3.6%). Similarly, Turon exhibited a reduction from 755 to 727 g/dm^3 (3.7%), while Qahrabo showed a decrease from 732 to 705 g/dm^3 (3.7%). The lowest final value was recorded in Navruz, decreasing from 717 to 691 g/dm^3 (3.6%).

Water absorption capacity declined considerably as well. In Durdona, this parameter decreased from 111% to 102%, corresponding to an 8.1% reduction. Radost showed a decrease from 108% to 99% (8.3%), while Turon dropped from 109% to 100% (8.2%). The greatest reduction occurred in Navruz, where water absorption declined from 103% to 95%, indicating a 7.8% decrease.

Table 1.

Changes in the Physical and Technological Properties of Mung Bean Grain After 6 Months of Storage

No.	Variety	Grain Mass, g	Bulk Density, g/dm^3	Water Absorption Capacity, %
1	Durdona	1,82	770	111
		1,81	768	109
		1,75	742	102
2	Radost	1,77	747	108
		1,76	745	106
		1,70	720	99
3	Turon	1,78	755	109
		1,77	753	107
		1,72	727	100
4	Qahrabo	1,73	732	106
		1,72	730	104
		1,66	705	97
5	Marjon	1,75	740	107
		1,74	738	105
		1,68	713	98
6	Navruz	1,70	717	103
		1,69	715	102
		1,63	691	95

The results demonstrate that the deterioration of physical and technological properties is closely associated with enhanced grain respiration, degradation of internal biochemical compounds, and the release of CO_2, which collectively contribute to mass loss. The reduction in bulk density indicates the formation of voids within the kernel structure, while the decline in water absorption capacity suggests increasing rigidity of cell walls. Among the tested varieties, Turon and Durdona exhibited the highest stability, whereas Navruz was the most sensitive variety, showing the greatest degree of deterioration.

These findings confirm the importance of monitoring physical and technological changes during long-term storage. Maintaining a stable microclimate is essential for preserving grain quality.

Under optimal storage conditions, physical characteristics showed minimal change. However, under non-standard microclimatic conditions, grain density decreased, yellowish spots appeared, and mechanical strength declined, all of which are associated with intensified respiration caused by elevated temperature and humidity.

Changes in Biochemical Composition.

After six months of storage, significant biochemical changes were observed in all mung bean varieties. According to the tabulated data, protein content decreased consistently across all varieties. For instance, in Durdona protein decreased from 24.8% to 24.1%, while in Radost it declined from 24.6% to 23.9%. A similar pattern was observed in Turon, Qahrabo, Marjon, and Navruz, with average reductions of 0.7–0.8%. This decrease is attributed to respiration during storage and the enzymatic breakdown of proteins.

The decline in starch content was even more noticeable. In Durdona, starch decreased from 56.7% to 54.8%; in Turon it declined from 57.1% to 55.0%; and in Navruz it decreased from 56.0% to 53.8%. Other varieties showed average reductions of 1.9–2.2%. Such decreases indicate the utilization of energy reserves, activation of hydrolytic enzymes, and acceleration of the physiological aging process of the grain.

Enzymatic Activity and Biochemical Changes. An increase in enzymatic activity was one of the most noticeable indicators during the six-month storage period. In the variety Durdona, enzymatic activity rose from 1.00 to 1.25 relative units, whereas in Radost and Marjon, the final values reached 1.22 and 1.22 units, respectively. In Turon, enzymatic activity increased to 1.23 units, indicating intensified metabolic processes. In Navruz, the increase was slightly lower at 1.20 units, yet still significant compared with the initial value.

These changes demonstrate that prolonged storage stimulates hydrolytic enzymes responsible for the breakdown of proteins and carbohydrates. This trend is consistent with observed decreases in protein and starch content, confirming that biochemical degradation accelerates as respiration intensifies and reserve substances are consumed.

Overall, the biochemical parameters of mung bean grains showed a consistent pattern of change throughout the six-month storage period. The reduction in protein content negatively affected the nutritional value of the grain, while the decrease in starch content led to deterioration in technological quality. The increase in enzymatic activity indicated that internal metabolic processes continued throughout storage, confirming that grain quality gradually declines as storage duration increases. Based on the tabulated data, Turon and Durdona were identified as the most stable varieties, whereas Navruz showed the highest sensitivity, displaying greater starch loss and more pronounced biochemical alterations.

The results demonstrate that the physical, technological, and biochemical properties of mung bean grain underwent significant changes during the six-month storage period. The physical and technological characteristics presented in Table 1, together with the biochemical changes indicated in Table 2, were closely interlinked, enabling the identification of key factors contributing to overall quality reduction.

First, the decline in grain mass and bulk density reflects the depletion of internal energy reserves. According to Table 1, grain mass decreased by an average of 0.06–0.07 g across all varieties. For instance, Durdona decreased from 1.82 g to 1.75 g, while Radost decreased from 1.77 g to 1.70 g. This 3–4% mass reduction indicates continued respiration and biological activity. Similarly, a 3.6–4.0% reduction in bulk density (e.g., Turon declining from 755 to 727 g/dm^3) suggests loosening of the internal grain structure and reduced mechanical strength. These findings are consistent with the reduction in starch content recorded in Table 2, confirming that substances responsible for structural integrity were being degraded.

Second, the reduction in water absorption capacity reflects deterioration in technological performance. Water absorption decreased by 7–12%, directly affecting cooking quality, softening behavior during boiling, and processing suitability. This change corresponded with the 1.9–2.2% decline in starch content reported in Table 2. As starch molecules undergo hydrolysis, the grain's ability to absorb water diminishes. For example, in Marjon, water absorption dropped from 107% to 98%, while in Navruz it declined from 103% to 95%.

Table 2.

Biochemical changes in mung bean grains during six months of storage

No.	Variety	Protein, %	Starch, %	Enzymatic Activity (Relative Units)

1	Durdona	24,8	56,7	1,00
		24,5	56,0	1,12
		24,1	54,8	1,25
2	Radost	24,6	56,2	1,00
		24,3	55,5	1,10
		23,9	54,3	1,22
3	Turon	25,0	57,1	1,00
		24,7	56,4	1,11
		24,3	55,0	1,23
4	Qahrabo	24,4	55,8	1,00
		24,1	55,2	1,09
		23,6	53,9	1,21
5	Marjon	24,7	56,5	1,00
		24,4	55,9	1,10
		24,0	54,6	1,22
6	Navruz	24,5	56,0	1,00
		24,2	55,3	1,09
		23,8	53,8	1,20

Third, the steady decline in biochemical composition closely paralleled the physical changes observed. Protein content decreased by an average of 0.7–0.8% across all varieties (e.g., Qahrabo declined from 24.4% to 23.6%), indicating that enzymatic degradation continued throughout storage. Likewise, a reduction of around 2% in starch content signaled depletion of the grain's energy reserves. These biochemical changes in turn contributed directly to reduced mass and bulk density.

Fourth, the increase in enzymatic activity was one of the most prominent indicators of ongoing metabolic processes. In Durdona, enzymatic activity increased from 1.00 to 1.25 relative units, while Radost, Turon, and Marjon reached 1.22–1.23 units. This represents a 20–25% rise in activity, signalling accelerated "biological aging," enhanced oxidation, and increased starch-breakdown reactions. These processes directly explained the decrease in density and the reduction in water absorption recorded in Table 1.

The results clearly show that physical and biochemical changes are strongly interconnected; deterioration in one parameter invariably affects others. For instance, a 2% reduction in starch content led to a 7–12% decline in water absorption capacity, while a 20–25% increase in enzymatic activity contributed to consistent reductions in grain mass and bulk density. Turon and Durdona emerged as the most stable varieties, as their rate of deterioration was slower than that of the other varieties. Navruz was the most sensitive variety, exhibiting the highest levels of starch loss, increased enzymatic activity, and reduced water absorption capacity.

These findings confirm that internal degradation processes continue throughout long-term storage and accelerate under suboptimal microclimatic conditions. Therefore, the effectiveness of mung bean storage depends directly on strict control of temperature, humidity, and ventilation within the storage facility.

Conclusion. The study clearly demonstrated that the physical, technological, and biochemical properties of mung bean grain undergo significant changes during six months of storage. The consistent decline in grain mass and bulk density (up to 3–4%) indicated gradual depletion of internal structure and energy reserves. The 7–12% reduction in water absorption capacity, linked to the hydrolysis of starch molecules, confirmed deterioration in technological quality. This was fully supported by the 1.9–2.2% decrease in starch content recorded in Table 2.

Biochemical changes—namely a 0.7–0.8% reduction in protein content and a 20–25% increase in enzymatic activity—revealed that metabolic activity continues during storage and that enzymatic processes accelerate the degradation of proteins and starch. The sharp rise in enzymatic activity was identified as a primary factor driving the loss of biochemical components and corresponding declines in physical characteristics.

The results show that mung bean grain is highly sensitive to long-term storage conditions. Turon and Durdona proved to be the most stable varieties, while Navruz exhibited the greatest susceptibility, with the highest levels of starch degradation, increased enzymatic activity, and the largest decline in water absorption capacity.

Overall, the findings confirm that strict microclimate control—especially maintaining low temperature, ensuring adequate air circulation, and regulating humidity—is crucial for preserving mung bean quality during storage. This study provides a valuable scientific and practical basis for improving long-term storage technologies for mung bean grain.

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