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# Physiological Potential of Bean Seeds under Different Storage Temperatures

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**Abstract**

Stored beans have active metabolism and respiration may cause significant quality losses. Therefore, some care is necessary during this period, aiming at maintaining the physiological quality of seeds, minimizing their deterioration and reducing their germinative power. Seed quality during storage may be influenced by environmental factors and the interaction of genotypes with the environment. The objective was to evaluate the germination and vigor of bean seeds after 90-days storage under different temperature conditions. The experiment was conducted under a completely randomized design, with four replications, in 3 × 2 factorial scheme, considering three storage temperatures (10 °C, 20 °C and 30 °C) and two storage times (0 and 90 days). For potential evaluation, the following characteristics were considered: moisture content, thousand seed mass, germination, electrical conductivity, accelerated aging and cold test. Numerical data were submitted variance analysis with averages compared by means test at 5% of significance. Results showed that storage temperature conditions directly affect physiological quality of bean seeds. Temperature of 10 °C provided better seed conservation whereas temperature of 30 °C promoted higher deterioration and reduced vigor.

**Keywords:** conservation, deterioration, germination, *Phaseolus vulgaris* L., quality analysis, vigor

## 1. Introduction

Common bean (*Plaseolus vulgaris* L.) is one of the most crops produced in Brazil with consumption practiced in several countries due to its low cost and relatively balanced nutritional content that propitiate ready acceptance by people with different eating habits (Borém & Carneiro, 2006).

Maintaining the physiological quality of seeds is important for grain selling. Thereby, it is necessary to investigate storage alternatives to maintain great characteristics for selling grains. It is also possible to reduce production losses in next harvest. Study of adequate storage conditions can provide the knowledge to maintain seed quality and increase shelf life of this food (Bragantini, 2005).

Storage conditions are fundamental to preserve physiological quality of seeds and promote longevity of products until consumption. Among influential factors, temperature and air humidity are the main ones that can modify initial state of seeds. Air moisture controls water content in seeds, while temperature affects chemical processes speed (Goldfarb & Queiroga, 2013).

Seed deterioration process derives from physiological, metabolic or biochemical changes (Oliveira et al., 1999). After harvesting, respiration and other metabolic processes in grains remain active, causing, in most cases, significant quality loss. For this reason, some care is necessary during storage for seeds quality maintenance and reduction of germinative power and deterioration (Brackmann et al., 2002).

Storage conditions are essential to preserve quality of bean seeds to maintain quality maintenance and it depends on genetic, environmental factors and the interaction with environment (Vieira & Yokoyama, 2000).

Seeds quality during storage periods suffers influences from environmental factors, mainly humidity and heat, by the interaction of genotypes with environment as well as genetic constitution of seed (Vieira & Yokoyama, 2000).

Then, bean seeds will possibly have their quality preserved for longer time if stored under optimized conditions (Toledo & Marcos Filho, 1977).

Storage temperature influences directly pests incidence in stored seeds. Weight reduction points to quality loss, as well as, lower food quality and germinative power, besides commercial value depreciation related to the presence of dead insects, eggs and excrements (Faroni & Silva, 2008).

According to problems above mentioned, knowing about the influence of different storage temperatures can provide better decisions about bean seeds storage. This work aimed at evaluating germination and vigor of bean seeds stored for 90 days under different temperature conditions (10 °C, 20 °C and 30 °C).

## 2. Materials and Methods

The experimental design was completely randomized with 3 × 2 factorial design, with three storage temperatures (10 °C, 20 °C and 30 °C) and two storage times (0 and 90 days), with four replications. Bean seeds used were of IPR Tangará cultivar.

First tests were carried out to evaluate initial physiological potential. An initial sample was divided into three sub-samples of two kilograms, stored under different temperature conditions for 90 days. For all subsamples, seeds were packed in a paper bag, wrapped in a plastic bag for storage.

Sample 01 was stored at refrigeration condition (10 °C). Sample 02 was buried in soil at depth of approximately 50 cm and 20 °C. Sample 03 was stored at 30 °C with constant light. Passed 90 days the same tests were done to check any changes in physiological quality of each sample.

Moisture content determination was possible using forced-air oven method, at 105±3 °C for 24 hours, with four repetitions of 10 grams for each treatment, recommended by Seed Analysis Rules (RAS) (Brasil, 2009). Results were expressed in percentage.

Thousand-grains mass was obtained by direct weighing of one thousand seeds, with four replicates for each treatment, using a precise scale. Results were expressed in grams.

Germination test was fulfilled according to RAS recommendations (Brasil, 2009), implemented on germitest paper with four subsamples of 50 seeds each. Papers previously moistened with deionized water in a proportion of 2.5 times of its weight received the seeds over two paper-layers, being covered with a third one, then rolled. Rolls were packed into BOD (body oxygen demand) chamber, at 25 °C. Two counting of normal seedlings were done at fifth and ninth day. Results were expressed in percentage.

For accelerated aging test, each treatment had 200 seeds per repetition, placed in simple layer under the surface of a metallic screen suspended inside plastic boxes with lid (Gerbox) containing 40 mL of distilled water. Treatments were conditioned at 42 °C for 72 hours (Marcos Filho, 1999). Passed this period, four subsamples of 50 seeds per replicate were submitted to germination test previously described.

For electrical conductivity test, disposable plastic cups (200 mL capacity) containing 75 mL of distilled water allocated 50 seeds. Cups were kept into BOD chamber at 25 °C (Vieira, 1994). Reading occurred after 24 hour-soak with submersion of conductivity meter probe in the sample. Results were expressed in $\mu S\ cm^{-1}g^{-1}$.

Modified cold test was performed using four 50-seeds subsamples distributed on germitest paper previously wetted (2.5 times paper weight). The rolls placed and sealed in plastic bags, were kept in cold chamber at 10 °C for five days. In sequence, they were transferred to the germinator at 25 °C, remaining for five days, from what on normal seedlings counting happened (Brasil, 2009).

Numerical data were submitted to Variance Analysis and means compared by Tukey test at error probability of 5%, through statistical software Sisvar® 5.6 (Ferreira, 2011).

## 3. Results

Different storage conditions influenced significantly ($p < 0.01$) in moisture content (MC), one-thousand seeds mass (OTSM), germination (GER), electrical conductivity (EC) and accelerated aging (AA) (Table 1). Cold test parameter (CT) presented significant difference only at 5% ($p < 0.05$).

Table 1. Summary of variance analysis for moisture content (MC), mass of one thousand seeds (OTSM), germination (GER), electrical conductivity (EC), accelerated aging (AA) and cold test (CT) of bean seeds stored at 10 °C, 20 °C and 30 °C for 90 days

| Variation Source | df | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | MC | OTSM | GER | EC | AA | CT |
| Storage | 3 | 0.75** | 36.23** | 8.25** | 233.42** | 1203.67** | 28,92* |
| Error | 12 | 0.12 | 3.23 | 28.42 | 23.96 | 13.67 | 6,92 |
| Average | | 12,87 | 276.69 | 94.62 | 89.37 | 85.25 | 87.62 |
| CV (%) | | 2,75 | 0.65 | 5.63 | 5.48 | 4.34 | 3.00 |

*Note*. *, ** significant $p < 0.05$, and significant $p < 0.01$, respectively, by the $F$ test.

Table 2 shows average results for moisture content (MC), one-thousand seeds mass (OTSM) and germination (GER). Temperature storage of 30 °C came out to the lowest results for MC and OTSM parameters, 12.25% and 272.5 g respectively. These results can be explained by the constant presence of light combined with high temperature, providing moisture exchange with the environment, causing loss of water in seeds. Germination percentage was significantly affected after storage. This may have occurred because seeds absorbed air moisture to stabilize humidity between the environment and the seed, affecting the germination.

Table 2. Mean values for moisture content (MC), one-thousand seeds mass (OTSM) and germination (GER) of bean seeds, stored at 10 °C, 20 °C and 30 °C for 90 days

| Treatments | MC (%) | OTSM (g) | GER (%) |
|---|---|---|---|
| Control, 0 days | 13.0 a | 276.5 a | 98.5 a |
| 10 °C, 90 days | 13.25 a | 278.7 a | 93.0 b |
| 20 °C, 90 days | 13.0 a | 279.0 a | 94.5 b |
| 30 °C, 90 days | 12.25 b | 272.5 b | 94.5 b |

*Note*. Means followed by the same lowercase letter in the column do not differ from each other by the Tukey test at 5% of error probability.

Average results for electrical conductivity (EC), accelerated aging (AA) and cold test (CT) show storage interference (Table 3). Electrical conductivity was less impaired in the treatment with seeds stored at 10 °C, without wide deterioration. Seeds stored at 30 °C presented greater damage to the cell membranes (97 µS $cm^{-1}g^{-1}$), that is to say greater seeds deterioration were originated from high temperature. The highest temperature also decreased germination percentage in accelerated aging test (59.5%) and cold test (84.5%). Seed storage at 10 °C undergone few changes on seeds electrolytes losses. Storage period increased electrical conductivity and seeds that remained at 30 ºC degraded easily.

Table 3. Mean values for electrical conductivity (EC), accelerated aging (AA) and cold test (CT) of bean seeds stored at 10 °C, 20 °C and 30 °C for 90 days

| Treatments | EC (µS $cm^{-1}g^{-1}$) | AA (%) | CT (%) |
|---|---|---|---|
| Control, 0 days | 79.25 a | 96.5 a | 91.0 a |
| 10 °C, 90 days | 88.25 ab | 94.5 a | 88.0 ab |
| 20 °C, 90 days | 93.00 b | 90.5 a | 87.0 ab |
| 30 °C, 90 days | 97.00 b | 59.5 b | 84.5 b |

*Note*. Means followed by the same lowercase letter in the column do not differ from each other by the Tukey test at 5% of error probability.

## 4. Discussion

Ideal storage conditions for bean seeds may propitiate a delay in its commercialization, and also offering quality seeds for next harvest. Seeds decrease germination ability when submitted to storage for 90 days, indicating quality drop. Temperatures of 10 °C maintained physiological quality of bean seeds, delaying physiological potential loss.

The difference in moisture content and seed weight can be explained by seeds characteristics, which gain or lose water to reach their hygroscopic equilibrium. Also, water movement depends on climatic conditions variation, such as temperature and humidity, besides chemical composition of seeds (Almeida et al., 2013).

Physiological quality of bean seeds in natural storage promotes a linear decline for water content values as storage time increases, reaching loss of 3.9% moisture at 16th month (Pinheiro et al., 2013), similar to this work. Zucareli et al. (2015) found remarkable reduction in physiological quality of carioca beans stored under ambient conditions (without control of temperature and humidity) compared to storage in controlled environment.

Alencar et al. (2009) noticed that grains stored at temperatures of 30 and 40 °C have more intense respiration, although humidity also influences grains metabolism. High water content is the main cause of physiological quality decrease of stored seeds (Goldfarb & Queiroga, 2013), what, according to Alencar et al. (2009) leads to qualitative deterioration process under high temperatures.

Bean seeds establish humidity balance to the environment, losing or gaining moisture. At 10 °C, a small increase in moisture was provided as well as a decrease on bean seeds germination, due to the deterioration of cell membranes and adaptation to the environment. Germination of seeds provided from accelerated aging test also showed a reduction at temperature of 30 °C, from 96.5% in control to 59.5% in treatment.

Deterioration process during storage is inevitable. Seeds lose vigor and germination capacity, however, storage conditions may delay this physiological alteration. Storage period at any temperature resulted in significant decrease for germination percentage when compared to control (Table 2), however, seeds kept minimum standards for marketing (80%), established by Agriculture Livestock and Supply Ministry (Mapa, 2013).

In this study, germination percentage and emergence speed decreased due to storage time. Maia et al. (2011) includes the influence of genetic variability associated with germination and emergence among white bean strains. Reduction on seed germination percentage of two bean varieties submitted to storage was also observed by Avaci et al. (2010).

Santos et al. (2005) evaluated the behavior of bean cultivars during 8-months storage, noticing that 80% of samples presented a linear decrease in germination. In this study, stored bean seeds lost physiological quality, this alteration probably derived from a higher intensity of cell membrane system disruption (Rigueira et al., 2009) observed in bean seeds stored for 120 days, as time passed by.

Avaci et al. (2010) analyzed physiological quality of two bean varieties during 30-days storage for what time provided higher electrical conductivity in seeds, increasing seed damage. Opposite results were found by Cassol et al. (2012) who observed no significant difference between storage times of 0 and 90 days in bean seeds. This may be explained by differences in tests driving conditions.

Such as in the present work, storage period of Rioja bean seeds resulted in vigor drop (Zucareli et al., 2015). Seeds of bean, rice and corn showed vigor drop from second-month storage on, accentuating at fourth month, through accelerated aging test evaluation (Silva et al., 2010).

Time promotes decline in physiological potential, reducing germination capacity and increasing sensitivity to environmental adversities with consequent seed vigor reduction (Marcos Filho, 2005). Results demonstrated that bean seeds can germinate after being subjected to adverse conditions.

For cold test, control (0 days) presented germination of 91% while treatments submitted to constant light for 90 days at 30 °C displayed germination of 84.5% (Table 3). Bean seeds stored at high temperature affect seed development and quality. Other treatments submitted to 10 °C and 20 °C did not differ from control. Germination decrease is influenced by high temperatures and relative humidity, the longer the exposure to these conditions, the greater the damage to seeds (Binotti et al., 2008). Germination percentage of bean seeds submitted to the cold test decreases over the period of eight months of storage (Silva et al., 2010), but in this study 90-days storage was long enough to provoke decline on this parameter.

## 5. Conclusion

Storage temperature affects directly physiological quality of bean seeds. We observed that storage temperature of 10 °C provided better seeds conservation. The temperature of 30 °C provided higher deterioration and reduced vigor, decreasing quality and durability.

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