ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.26, n.9, p.649-654, 2022
agriambi
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v26n9p649-654

Chickpea seed storage in different packagings, environments and periods[1]

Armazenamento de sementes de grão de bico em diferentes embalagens, ambientes e períodos

Amanda M. Silva[2*], Josiane C. Figueiredo[2], Lilian V. M. de Tunes[3], Gizele I. Gadotti[4], Daniele B. Rodrigues[5] & André F. Capilheira[6]

[1] Research developed at Pelotas, RS, Brazil
[2] Universidade Federal de Pelotas/Departamento de Fitotecnia, Pelotas, RS, Brazil
[3] Universidade Federal de Pelotas/Faculdade de Agronomia Eliseu Maciel/Departamento de Fitotecnia, Pelotas, RS, Brazil
[4] Universidade Federal de Pelotas/Unidades e Cursos de Graduação/Centro de Engenharias, Pelotas, RS, Brazil
[5] Associação dos Produtores de Sementes do Mato Grosso/Laboratório de Análise de Sementes, Rondonópolis, MT, Brazil
[6] Fundação Pró Sementes, Passo Fundo, RS, Brazil

HIGHLIGHTS:

Cold chamber storage environment favors the quality of chickpea seeds.
Storage period significantly influences the quality of chickpea seeds.
Kraft® paper packaging is more efficient for storing chickpea seeds.

ABSTRACT: Storage is a fundamental practice in the control of the physiological quality of seeds, as it is a method that can preserve their viability and vigor for a longer period. Thus, the objective of the present study was to evaluate the storage of chickpea seeds in different packagings, environments, and periods. The completely randomized design was used in a 2 × 2 × 4 factorial scheme, corresponding to two types of packaging (hermetic and Kraft® paper), two storage environments (cold chamber environment and conventional environment), and four storage periods (0, 45, 90, and 135 days), with four replicates. The seeds were placed in Kraft® paper bags and hermetic packagings and stored for 135 days in the environments: cold chamber (14.5 °C and relative air humidity of 65%) and conventional environment (no temperature and relative air humidity control). Every 45 days, seeds were subjected to the following evaluations: determination of water content, germination, first germination count and accelerated aging. In general, the maintenance of the physiological quality of chickpea seeds was verified in Kraft® paper packagings and the cold chamber environment. Storage of chickpea seeds in hermetic packaging must be carried out with seeds with 7% moisture, regardless of the storage environment. The packagings maintained the physiological quality of chickpea seeds for up to 45 days, regardless of the storage environment.

Key words: *Cicer arietinum* L., hermetic packaging, physiological quality, vigor

RESUMO: O armazenamento é uma prática fundamental no controle da qualidade fisiológica das sementes, pois é um método que pode preservar sua viabilidade e vigor por mais tempo. Assim, o objetivo do presente estudo foi avaliar o armazenamento de sementes de grão-de-bico em diferentes embalagens, ambientes e períodos. O delineamento inteiramente casualizado foi utilizado em esquema fatorial 2 × 2 × 4, sendo dois tipos de embalagens (hermética e papel Kraft®), dois ambientes de armazenamento (ambiente de câmara fria e ambiente convencional) e quatro períodos de armazenamento (0, 45, 90 e 135 dias), com quatro repetições. As sementes foram acondicionadas em sacos de papel Kraft® e embalagens herméticas, e armazenadas por 135 dias nos ambientes: câmara fria (14,5 °C e umidade relativa do ar de 65%) e ambiente convencional (sem controle de temperatura e umidade relativa do ar). A cada 45 dias, as sementes foram submetidas às seguintes avaliações: determinação do teor de água, germinação, primeira contagem de germinação e envelhecimento acelerado. Em geral, a manutenção da qualidade fisiológica das sementes de grão de bico foi verificada em embalagens de papel Kraft® e em ambiente de câmara fria. O armazenamento de sementes de grão de bico em embalagens herméticas deve ser realizado com sementes com 7% de umidade, independente do ambiente de armazenamento. As embalagens mantiveram a qualidade fisiológica das sementes de grão de bico por até 45 dias, independente do ambiente de armazenamento.

Palavras-chave: *Cicer arietinum* L., embalagem hermética, qualidade fisiológica, vigor

• Ref. 256876 – Received 30 Sept, 2021
* Corresponding author - E-mail: martins.amanda33@gmail.com
• Accepted 24 Apr, 2022 • Published 12 May, 2022
Editors: Josivanda Palmeiras Gomes & Carlos Alberto Vieira de Azevedo

Introduction

Chickpea (*Cicer arietinum* L.) belongs to the legume family and plays an important role in human nutrition (Merga & Haji, 2019), being one of the most consumed legumes in the world, second only to soybeans (Swamy et al., 2020).

Storage is an excellent alternative to meet the logistics of the production and sale of seeds. Thus, information on the behavior of seeds in the face of the probable climatic conditions that occur during storage can help make the storage based on the cost-benefit ratio, resulting from possible losses of quality during storage.

Environmental conditions related to temperature, relative air humidity, and water content of seeds should be taken into account during storage, as unfavorable conditions lead to reduced longevity of seeds (Suriyong et al., 2015).

Among the factors mentioned above, seed moisture content is considered the main factor affecting seed longevity, as it can induce to high respiratory rate and consumption of energy reserves (Martins & Pinto, 2014; Wang et al., 2018; Ullmann et al., 2018).

Another factor that interferes with the physiological quality of seeds is the type of packaging used (Marcos Filho, 2015); the packaging for seed storage, available on the market, has permeable, semi-permeable or impermeable characteristics, each with a different degree of protection regarding variations in air humidity and hygroscopicity (Baudet & Villela, 2019).

However, there are few studies in the literature on the storage of chickpea seeds, especially regarding the environment and ideal storage temperature, and the best packaging. Thus, the objective of this study was to evaluate the storage of chickpea seeds in different packagings, environments, and storage periods.

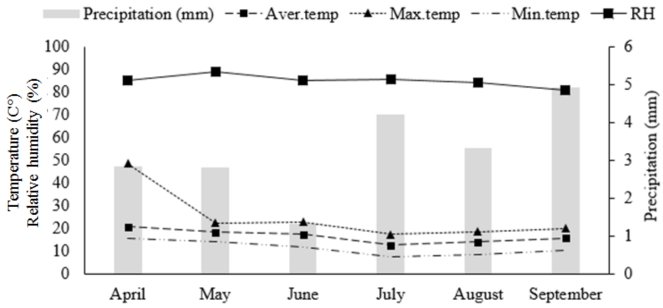
Material and Methods

The experiment was conducted at the Seed Analysis Didactic Laboratory "Flávio Farias da Rocha" of the Graduate Program in Seed Science and Technology at the Federal University of Pelotas. A lot of chickpea seeds, cultivar Aleppo from the 2019/2020 growing season, was used. After harvesting and processing the seeds, the experiment was set up.

The completely randomized design was used in a 2 × 2 × 4 factorial scheme, corresponding to two types of packaging (hermetic and Kraft® paper), two storage environments (cold chamber environment and conventional environment), and four storage periods (0, 45, 90, and 135 days), with four replicates.

From the seed lot, 1.5 kg were taken and placed in each of the aforementioned packagings and stored in a conventional environment, without temperature and relative air humidity control, and in a cold chamber set at 14.5 °C and relative air humidity of 65%. From the same original lot, a representative sample was taken and the physiological quality was evaluated, whose data obtained were taken as a result of month zero of storage.

The meteorological data recorded during the experimental period are illustrated in Figure 1.



Aver.temp – Average temperature; Max.temp – Maximum temperature; Min.temp – Minimum temperature; RH – Relative air humidity

Figure 1. Monthly data of rainfall, relative air humidity and temperature recorded at the Instituto Nacional de Meteorologia - Pelotas Station, Brazil, during the experimental period, year 2020

To assess the physiological quality in the different storage periods, the following assessments were performed:

Seed water content: it was determined by the standard oven method at 105 ± 3 °C for 24 hours (Brasil, 2009).

Germination test: 50 seeds per treatment were sown between sheets of germitest paper, in the form of rolls and moistened with a volume of distilled water equivalent to 2.5 times the dry weight. The rolls were placed in a germinator at a temperature of 20 °C. The evaluations were carried out on the fifth and tenth day after sowing, and the results were expressed as a percentage of normal seedlings, according to criteria established by Brasil (2009).

First germination count: it was carried out along with the germination test with evaluation on the fifth day after sowing, with the results expressed in percentage, according to Brasil (2009).

Accelerated aging: a single layer of 300 seeds was evenly distributed on an aluminum screen coupled to the gerbox (11 × 11 × 3.5 cm), containing 40 mL saturated sodium chloride solution (40 g of NaCl for 100 mL distilled water). Gerboxes were covered and kept in a BOD chamber, at 40 °C for 24 hours. After this period, the germination test was carried out, with four replicates of 50 seeds per treatment, in which counting was performed on the fifth day, according to the criteria established in the Rules for Seed Analysis (Brasil, 2009).

Data obtained were tested for normality and homogeneity of variances and then subjected to analysis of variance. In addition, effects of storage packagings and storage environments were studied by the F test at $p \leq 0.05$. The effects of storage periods were tested by regression analysis, selecting the appropriate models to represent them based on their biological behavior, on the significance of the model coefficients and on the value of the coefficient of determination (R^2). For data analysis, the statistical software R was used (R Core Team, 2017).

Results and Discussion

There was a significant effect of the triple interaction between the factors for the variable water content (Table 1). The double interaction was significant for the packaging and storage period factors for germination and first germination count. In relation to accelerated aging, there was a significant

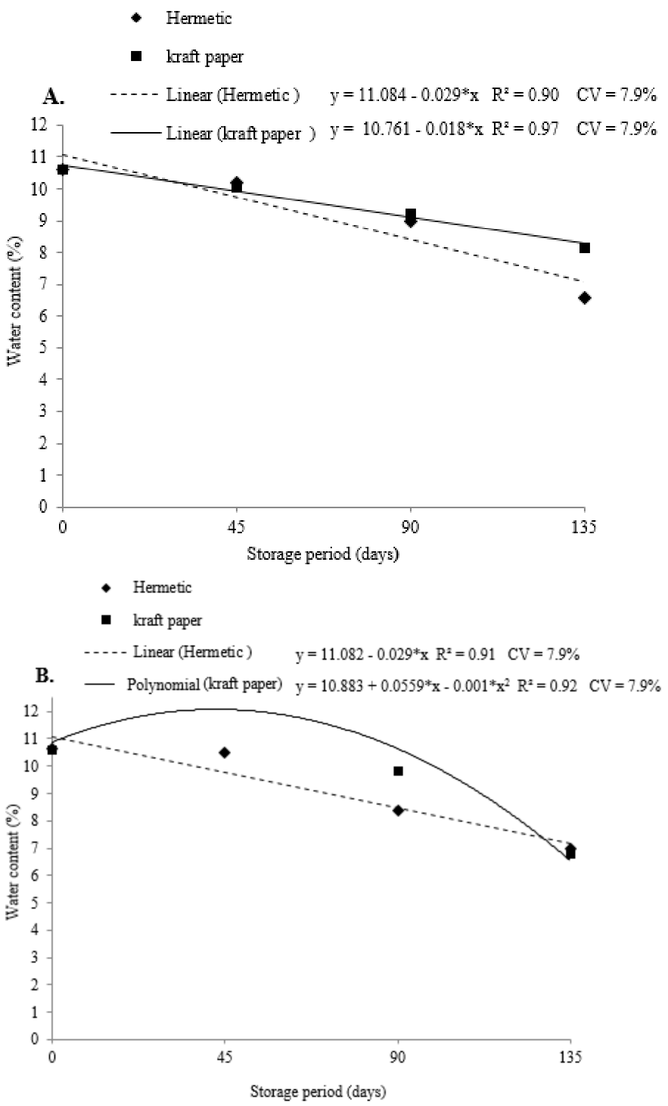
Table 1. Analysis of variance for the variables water content (WC), germination (GER), first germination count (FGC), and accelerated aging (ACA) of chickpea seeds stored in different packagings, environments and periods

Source of variation	DF	Mean square			
		WC	GER	FGC	ACA
Packaging (Pa)	1	7.310*	36.000^{ns}	115.562^{ns}	10.562^{ns}
Environment (En)	1	1.131*	812.250*	14.062^{ns}	798.062*
Period (Pe)	3	47.958*	8721.166*	6877.895*	9205.395*
Pa × En	1	0.924*	240.250^{ns}	85.562^{ns}	370.562*
Pa × Pe	3	0.938*	235.500*	306.895*	44.062^{ns}
En × Pe	3	3.164*	153.416^{ns}	67.729^{ns}	248.895*
Pa × En × Pe	3	3.171768*	73.750^{ns}	21.562^{ns}	174.729^{ns}
Residual	48	0.005	74.833	74.395	66.062
Total	63				
CV (%)		7.9	13.62	17.73	13.62

**, ns - Significant and not significant by F-test at p ≤ 0.05, respectively

effect of the double interactions between the packaging and environment factors, and between environment and storage period factors.

In the cold chamber environment (Figure 2A), the water contents of the seeds throughout the storage period showed



* - Significant at p ≤ 0.05 by F test

Figure 2. Water content of chickpea seeds stored in a cold chamber (A) and conventional storage (B) as a function of storage period for different storage packagings

a linear behavior for the packagings. In the initial evaluation period, seeds stored in hermetic and Kraft® paper packagings had an estimated water content of 10.76%. However, during the storage period, the water content of seeds for both packagings decreased, reaching the lowest percentages of 7.09 and 8.29% moisture, respectively, at the end of evaluation period. Thus, the results obtained represented reductions in the water content of seeds of 34.10 and 22.95%, respectively, compared to the initial evaluation (period 0).

The decrease in the percentage of water content over the months of storage can be attributed to the hygroscopicity of the seed, that is, it has the property of absorbing or transferring water to the surrounding air (Oliveira et al., 2014; Costa et al., 2015). Humidity variations inside the packagings during storage cause variations in the water content of seeds during this period, since the seed has hygroscopic tissues (Capilheira et al., 2019).

As for the conventional environment (Figure 2B), the water content of the seeds stored in hermetic and Kraft® paper packagings showed linear and quadratic behavior, respectively. Considering the results obtained with seeds stored in hermetic packaging, the water content, which was 10.76% at the beginning of storage, decreased until reaching its lowest value (7.10%) in the last evaluation period (135 days). In turn, seeds stored in Kraft® paper packaging showed an increase in water content, reaching 13.26% at 43 days of storage with a further reduction in this percentage, at 135 days, in which the water content was 6.53%.

The storage of seeds in permeable packagings allows the internal humidity to change with the environment, causing increases or decreases in the water content until reaching hygroscopic equilibrium (Rocha et al., 2017; Moreano et al., 2018; Keneni et al., 2019). Smaniotto et al. (2014) evaluated the storage of soybean seeds and observed a reduction in the water content, to 11%, due to the permeability of the packaging, which allowed greater intensities of water vapor exchange with the environment. However, under conventional environment conditions, there is variation in relative air humidity throughout the year, with a consequent activity in seed moisture content, while under controlled environment conditions, the variation is minimal. In the city of Pelotas, RS, Brazil, where the experiment was carried out, the highest relative air humidity occurs in May (Figure 1), when the evaluations were carried out, which explains the higher moisture content of seeds stored in the conventional environment. Silva et al. (2019), studying the storage of sorghum seeds in the city of Botucatu, SP, Brazil, observed that the lowest moisture contents of the seeds stored in a natural laboratory environment were obtained in July, when the lowest relative air humidity was observed. Thus, the increase in the water content of seeds in the Kraft® paper packaging can be justified by fluctuations in weather conditions observed during seed storage (Figure 1). According to Baudet & Villela (2019), when stored in permeable packagings, seeds change their water content as a function of variations in relative air humidity, as they are hygroscopic.

According to Table 2, for the cold chamber environment at 45 days of storage, there was no difference between the packagings; on the other hand, at 90 and 135 days, seeds

Table 2. Water content (%) of chickpea seeds stored in different environments, packagings and periods

Period (days)	Environment	Packaging	
		Kraft® paper	Hermetic
0	Cold chamber	10.62 aA	10.62 aA
	Conventional	10.62 aA	10.62 aA
45	Cold chamber	10.07 bA	10.17 bA
	Conventional	12.85 aA	10.50 aB
90	Cold chamber	9.25 bA	8.96 aB
	Conventional	9.85 aA	8.37 bB
135	Cold chamber	8.15 aA	6.59 bB
	Conventional	6.79 bA	6.96 aA

For the same storage period, means followed by different uppercase letters, in the same row (packagings), and lowercase letters, in the same column (environments), are significantly different from each other by F-test at $p \leq 0.05$

stored in the Kraft® paper packaging had higher water content, compared to those stored in the hermetic packaging.

Changes in the water content of seeds in the present study can be explained by the fact that the cold chamber was frequently opened during some periods, causing fluctuations in temperature and humidity. And the permeable packagings do not offer any resistance to the exchange of water vapor between seeds and the environment in which they are stored; thus, the water content of seeds stored in permeable packagings varies according to variations in relative air humidity, because they are hygroscopic (Hornke et al., 2020). In the conventional environment, at 45 and 90 days of storage, the lowest percentage of the water content of seeds was found for the hermetic packaging (Table 2).

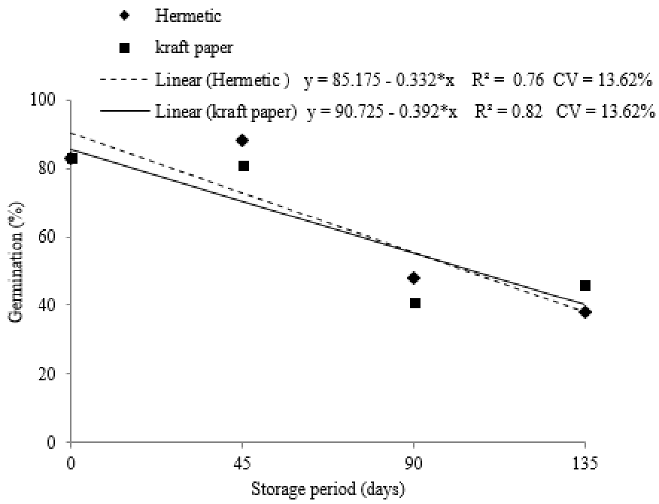
According to Marcos Filho (2015), moisture content is one of the factors that most affect the metabolic activity of seeds and, therefore, can determine the maintenance of embryonic viability and seed quality during storage. For orthodox seeds, these can be dried to low water contents between 5 and 7% and stored at low temperatures (Costa, 2009). However, Harrington (1972) considers the water contents for orthodox seeds between 5 and 14% and storage temperature between 0 and 50 °C. To maintain viability throughout the storage period, a 1% reduction in seed water content doubles the viability period as well as a decrease of 5.6 °C in temperature.

The germination percentage of seeds stored in both packagings decreased linearly over the storage period (Figure 3). The germination percentage, which was 83% at the beginning of storage, reduced until reaching its lowest value of 46 and 38%, respectively, in Kraft® and hermetic paper packagings after 135 days of storage (Figure 3).

This may be because chickpea seeds were packed in waterproof packaging with humidity above 10%. This humidity condition is considered high compared to hermetic packaging standards, which favors the seed deterioration process. Satasiya et al. (2021) also observed a reduction in chickpea seed germination under natural conditions during the seed storage period.

When studying the effect of packaging within each storage period, it is verified that there was a difference in the germination percentage of seeds only in the storage period of 135 days, and the seeds stored in Kraft® paper packaging had higher germination percentages (Table 3).

Thus, permeable packaging such as paper allows for gas exchange between the seed and the environment, while



* - Significant at $p \leq 0.05$ by F test

Figure 3. Chickpea seed germination as a function of storage period for different packagings

Table 3. Chickpea seed germination as a function of packaging for different storage periods

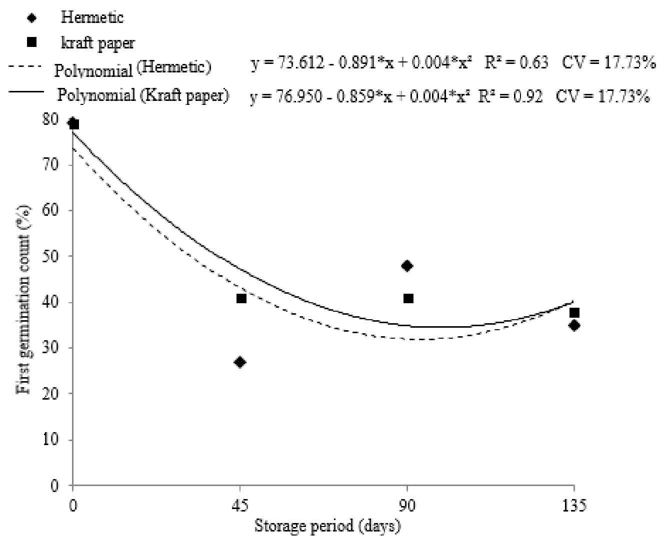
Packaging	Storage period (days)			
	0	45	90	135
Hermetic	83 a	81 a	48 a	38 b
Kraft® paper	83 a	88 a	42 a	46 a

Means followed by different letters on the same column are significantly different by the F test at $p \leq 0.05$

hermetic packaging restricts such exchange (Ferreira & Bazzo, 2020). In the same study, it was possible to verify that the analyzed variables showed a significant drop when the seeds were packed in plastic packaging under a natural environment condition.

It is worth mentioning that in the initial period of storage the seeds showed a minimum percentage of germination (80%) acceptable for the commercialization of chickpea seeds (Brasil, 2012).

When evaluating the vigor of seeds by first germination count, a quadratic regression equation fitted to the results (Figure 4). There was a reduction in the vigor of seeds stored



* - Significant at $p \leq 0.05$ by F test

Figure 4. First germination count of chickpea seeds as a function of storage period for different packagings

in hermetic packagings up to 90 days of storage. As for the Kraft® paper packaging, in the initial period of assessment, the seeds showed vigor of 72%, decreasing sharply until 90 days of storage, reaching a vigor of 35%. Similar results obtained in this study were observed by Silva et al. (2010), who also observed that rice, corn and bean seeds, stored in permeable packaging at chamber temperature, showed decrease in vigor over storage time.

According to Marcos Filho (2015), the maintenance of vigor may be related to the moisture variations observed according to the hermetic packagings used and the concentration of O_2 inside the packagings, which interfere with the seed metabolism.

When studying the effect of packagings within each storage period, it is verified that with 45 and 135 days of storage, seeds stored in Kraft® paper packaging were more vigorous compared to those stored in hermetic packaging (Table 4).

It is noteworthy mentioning the lower performance from the storage of seeds in hermetic packaging due to improper storage humidity affecting the metabolism of seeds to the point of compromising their vigor (Antonello et al., 2009).

According to Donadon et al. (2015), among the physiological symptoms most strongly affected by the seed deterioration process are those related to vigor; this occurs due to the disruption of the membrane system through the attack of its cellular constituents by free radicals, triggering serious damage during the growth and formation of seedlings.

Regarding accelerated aging, there was no statistical difference between the packagings in any of the environments (Table 5). However, seeds stored in Kraft® paper packaging in the cold chamber were more vigorous when compared to those stored in the conventional environment. Similar results were reported by Almeida et al. (2010), who emphasize that the physiological quality of stored oilseeds is better when they are kept in a controlled temperature environment.

Regarding the analysis of storage periods (Figure 5), at the beginning of storage, seeds showed a vigor of 83%, decreasing linearly for both storage environments, reaching the lowest percentages of 29.14 and 42.79% for the conventional environment and cold chamber, respectively.

Seeds stored in a controlled environment tend to be preserved for a longer time, as with the use of a reduced temperature there can be less loss of water to the environment.

Table 4. First germination count of chickpea seeds as a function of packagings for different storage periods

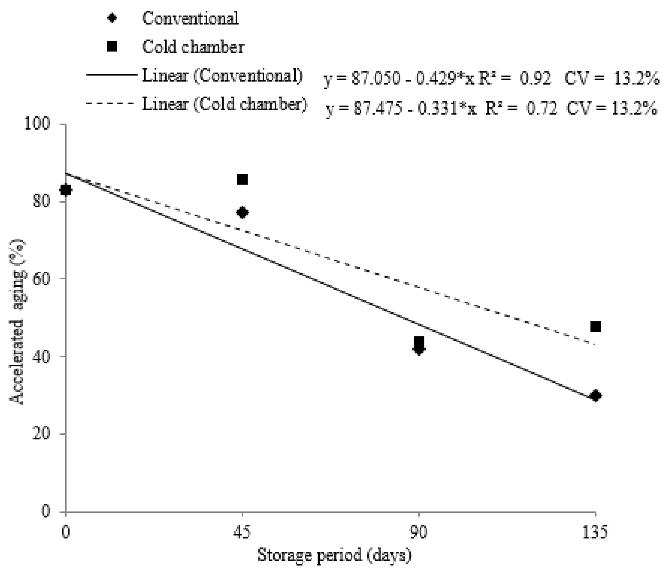
Packaging	Storage period (days)			
	0	45	90	135
Hermetic	79 a	27 b	41 a	35 b
Kraft® paper	79 a	45 a	48 a	39 a

Means followed by different letters on the same column are significantly different by the F test at $p \leq 0.05$

Table 5. Accelerated aging of chickpea seeds stored in different packagings and environments

Environment	Packaging	
	Hermetic	Kraft® paper
Conventional	61 aA	55 bA
Cold chamber	63 aA	67 aA

Means followed by different uppercase letters, in the same row (packaging), and lowercase letters, in the same column (environment), are significantly different by F-test at $p \leq 0.05$



* - Significant at $p \leq 0.05$ by F test

Figure 5. Accelerated aging of chickpea seeds as function of storage period in conventional environment and cold chamber

On the other hand, in environments without humidity and temperature control, the humidity in the air may be sufficient to promote the resumption of embryonic development (Gibbert et al., 2019).

In this context, the information obtained in this study helps determine the best strategies to be adopted to store chickpea seeds, seeking to obtain high-quality seeds.

Conclusions

1. In general, the maintenance of the physiological quality of chickpea seeds was verified in Kraft® paper packagings and in a cold chamber environment.

2. The storage of chickpea seeds in hermetic packaging must be carried out with seeds with 7% moisture, regardless of the storage environment.

3. The packagings maintained the physiological quality of the chickpea seeds for up to 45 days, regardless of the storage environment.

Acknowledgments

The authors thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) - Financing Code 001 for the financial support and granted scholarships.

Literature Cited

Almeida, F. de A. C.; Jerônimo, E. de S.; Alves, N. M. C.; Gomes, J. P.; Silva, A. S. Study of techniques for the storage of five oilseeds under environmental and cryogenic conditions. Revista Brasileira de Produtos Agroindustriais, v.12, p.189-202, 2010.

Antonello, L. M.; Muniz, M. F. B.; Brand, S. C.; Rodrigues, J.; Menezes, N. L. de; Kulczynski, S. M. Influência do tipo de embalagem na qualidade fisiológica de sementes de milho crioulo. Revista Brasileira de Sementes, v.31, p.75-86, 2009. https://doi.org/10.1590/S0101-31222009000400009

Baudet, L. M. L.; Villela, F. A. Armazenamento de sementes. In: Peske, S. T.; Villela, F. A.; Meneghello, G. E (eds). Sementes: Fundamentos científicos e tecnológicos. Pelotas: Ed. Becker e Peske, p.481-528, 2019.

Brasil. Sistema de Consulta à Legislação - SISLEGIS. Ministério da Agricultura, Pecuária e Abastecimento. Brasília: Secretaria de Defesa Agropecuária, 2012.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Brasília: Ministério da Agricultura, Pecuária e Abastecimento/Secretaria de Defesa Agropecuária, 2009. 395p.

Capilheira, A. F.; Cavalcante, J. A.; Gadotti, G. I.; Bezerra, B. R.; Hornke, N. F.; Villela, F. A. Storage of soybean seeds: Packaging and modified atmosphere technology. Revista Brasileira de Engenharia Agrícola e Ambiental, v.23, p.876-882, 2019. https://doi.org/10.1590/1807-1929/agriambi.v23n11p876-882

Costa, C. J. Armazenamento e conservação de sementes de espécies do Cerrado. Planaltina: Embrapa Cerrados, 2009.30p.

Costa, L. M.; Resende, O.; Oliveira, D. E. C. de. Determinação das isotermas de equilíbrio higroscópico de frutos de crambe pelo método dinâmico. Bioscience Journal, v.31, p.382-391, 2015. http://dx.doi.org/10.14393/BJ-v31n2a2015-22337

Donadon, J. R.; Bessa, J. F. V.; Resende, O.; Castro, C. F. de S.; Alves, R. M. V.; Silveira, E. V. S. Armazenamento do crambe em diferentes embalagens e ambientes: Parte II - Qualidade química. Revista Brasileira de Engenharia Agrícola e Ambiental, v.19, p.231-237, 2015. https://doi.org/10.1590/1807-1929/agriambi.v19n3p231-237

Ferreira, M. de F.; Bazzo, J. H. B. Tipos de embalagens e ambientes de armazenamento no potencial fisiológico de sementes de soja. Revista Terra & Cultura, v.36, p.157-172, 2020.

Gibbert, P.; Malavasi, M. de M.; Malavasi, U. C.; Dranski, J. A. L. Conservation of seeds of *Myrcianthes pungens* (Berg) Legr. in different packaging in a controlled environment. Revista Árvore, v.43, p.1-9, 2019. https://doi.org/10.1590/1806-90882019000200005

Harrington, J. F. Seed storage and longevity. In: Kozlowski, T. T. Seed Biology, insects, and seed collection, storage, testing, and certification. Academic Press, New York, v.3, p.145-245, 1972. https://doi.org/10.1590/S0102-053620200312

Hornke, N. F.; Gadotti, G. I.; Capilheira, A. F.; Cavalcante, J. A.; Nadal, A. P.; Silva, J. G. da S. Physiological potential of onion seeds stored in different packings and environments. Horticultura Brasileira, v.38, p.312-318, 2020.

Keneni, Y. G.; Hvoslef-Eide, A. T.; Marchetti, J. M. Mathematical modelling of the drying kinetics of *Jatropha curcas* L. seeds. Industrial Crops and Products, v.132, p.12-20, 2019.

Marcos Filho, J. Fisiologia de sementes de plantas cultivadas. 2.ed. Londrina: Abrates, 2015. 660p.

Martins, C. C.; Pinto, M. A. D. da S. C. Armazenamento de sementes de ipê-amarelo-do-brejo (*Handroanthus umbellatus* (Sond.) Mattos. Bignoniaceae). Ciência Florestal , v.24, p.533-539, 2014. https://doi.org/10.1590/1980-509820142403002

Merga, B.; Haji, J. Economic importance of chickpea: Production, value, and world trade. Food & Agriculture, v.5, p.1-13, 2019. https://doi.org/10.1080/23311932.2019.1615718

Moreano, T. B.; Marques, O. J.; Braccini, A. L.; Scapim, C. A.; França Neto, J. B.; Krzyzanowski, F. C. Evolution of the physical and physiological quality of soybean seeds during processing. Journal of Seed Science, v.40, p.313-322, 2018. https://doi.org/10.1590/2317-1545v40n3198414

Oliveira, D. E. C. de; Resende, O.; Campos, R. C.; Donadon, J. R. Obtenção e modelagem das isotermas de dessorção e do calor isostérico para sementes de arroz em casca. Científica, v.42, p.203-210, 2014. http://dx.doi.org/10.15361/1984-5529.2014v42n3p203-210

R Core Team. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing, 2017. Available on: <https://www.r-project.org/>. Accessed on: Feb. 2021.

Rocha, G. C.; Rubio Neto, A.; Cruz, S. J. S.; Campos, G. W. B.; Castro, A. C. de O.; Simon, G. A. Qualidade fisiológica de sementes de soja tratadas e armazenadas. Revista Científica, v.1, p.50-65, 2017.

Satasiya, R. M.; Antala, D. K.; Sojitra, M. A.; Kothiya, A. V.; Chauha, P. M. Effect of packaging on storage behaviour of chickpea grain. Journal of Pharmacognosy and Phytochemistry, v.10, p.1575-1584, 2021.

Silva, F. S. da; Porto, A. G.; Pascuali, L. C.; Silva, F. T. C. da. Viabilidade do armazenamento de sementes em diferentes embalagens para pequenas propriedades rurais. Revista de Ciências Agroambientais, v.8, p.45-56, 2010.

Silva, H. da; Toledo, M. Z.; Teixeira, R. N.; Rossi, R. F.; Nakagawa, J. Influence of the storage environment on the physiological quality of millet seeds (*Pennisetum glaucum* (L.) R. Br.). Journal of Seed Science, v.41, p.286-292, 2019. https://doi.org/10.1590/2317-1545v41n3208200

Smaniotto, T. A. de S.; Resende, O.; Marçal, K. A. F.; Oliveira, D. E. C. de; Simon, G. A. Qualidade fisiológica das sementes de soja armazenadas em diferentes condições. Revista Brasileira de Engenharia Agrícola e Ambiental, v.18, p.446-453, 2014.

Suriyong, S.; Krittigamas, N.; Pinmanee, S.; Punyalue, A.; Vearasilp, S. Influência das condições de armazenamento na alteração da qualidade de sementes de cânhamo. Agriculture and Agricultural Science Procedia, v.5, p.170-176, 2015. https://doi.org/10.1590/S0100-67622010000600005

Swamy, S. G.; Raja, D. S.; Wesley, B. J. Susceptibility of stored chickpeas to bruchid infestation as influenced by physico-chemical traits of the grains. Journal of Stored Products Research, v.87, p.1-5, 2020. https://doi.org/10.1016/j.jspr.2020.101583

Ullmann, R.; Resende, O.; Rodrigues, G. B.; Chaves, T. H.; Oliveira, D. E. C. de. Qualidade fisiológica das sementes de sorgo sacarino submetidas à secagem e ao armazenamento. Revista Engenharia na Agricultura, v.26, p.313-321, 2018. https://doi.org/10.13083/reveng.v26i4.960

Wang, W.; He, A.; Peng, S.; Huang, J.; Cui, K.; Nie, L. The effect of storage condition and duration on the deterioration of conditioned rice seeds. Frontiers in Plant Science, v.9, p.1-17, 2018. https://doi.org/10.3389/fpls.2018.00172