Physiological quality of eggplant seeds with different extraction and drying methods[1]

Leomara Vieira de França[2]*, Mariana Dierings Croda[3],
Warley Marcos Nascimento[3], Raquel Alves de Freitas[4]

ABSTRACT – During seed extraction in fleshy fruits, some procedures are necessary to ensure seed quality and minimize deterioration and microorganism activity; also seeds extracted under moist conditions need special care when drying. The objective of this study was to evaluate the physiological quality of eggplant seeds submitted to different extraction and drying methods. In the first study, whole eggplant fruits were mechanically crushed and then fermented for 0, 24 and 48 hours, with and without applying hydrochloric acid during seed extraction. In the second study, seeds were extracted in a pepper peeler and then immediately washed in water and submitted to the following drying methods: Sun/24 h; Sun/48 h; 32 °C/24 h; 32 °C/48 h; 38 °C/24 h; 38 °C/48 h; Sun/24 h + 32 °C/24 h; Sun/24 h + 38 °C/24 h e 32 °C/24 h + 38 °C/24 h. The treatment efficiency of both experiments was evaluated from the following tests: seed weight, germination, first count, accelerated aging and seedling emergence. The results suggest that fermentation and applying hydrochloric acid to pulp/seed reduce the physiological seed quality. All drying methods reduced the seed moisture content permitting adequate storage and maintenance of seed physiological quality.

Index terms: *Solanum melongena*, fermentation, hydrochloric acid, moisture, storage.

Qualidade fisiológica de sementes de berinjela submetidas a diferentes métodos de extração e secagem

RESUMO – A extração e secagem de sementes de frutos carnosos devem ser realizadas com cuidado para minimizar a deterioração e a presença de microrganismos durante o armazenamento. Objetivou-se neste trabalho avaliar a qualidade fisiológica de sementes de berinjela submetidas a diferentes métodos de extração e secagem. Foram realizados dois estudos: 1) Extração: frutos inteiros de berinjela foram esmagados mecanicamente e em seguida fermentados por períodos de 0; 24 e 48 horas, com ou sem aplicação de ácido clorídrico para a extração das sementes. 2) Secagem: sementes foram extraídas em descascador de pimenta-do-reino, imediatamente lavadas em água corrente e submetidas aos seguintes métodos de secagem: sol/24 h; sol/48 h; 32 °C/24 h; 32 °C/48 h; 38 °C/24 h; 38 °C/48 h; sol/24 h + 32 °C/24 h; sol/24 h + 38 °C/24 h e 32 °C/24 h + 38 °C/24 h. Para a avaliação da eficiência dos tratamentos de ambos experimentos foram realizados os testes de massa de 100 sementes, germinação, primeira contagem de germinação, envelhecimento acelerado e emergência de plântulas. Os resultados encontrados indicam que a fermentação e a aplicação de ácido clorídrico reduzem a qualidade fisiológica da semente. Os métodos de secagem utilizados mostraram-se capazes de reduzir a umidade das sementes para um teor de água compatível ao armazenamento adequado e de manter a qualidade fisiológica das sementes.

Termos para indexação: *Solanum melongena*, fermentação, ácido clorídrico, umidade, armazenamento.

Introduction

The search for new technologies, or even technological modifications in the seed production system, has been constant in seed research, resulting in changes in the various stages of the seed production process and leading to their improvement. The production process for the seeds species has a larger number of steps, as for example, for fleshy fruits, which need to be pulped and some species need specific processes, such as fermentation (Silva et al., 2009).

Natural fermentation consists of placing the seeds, together with the placenta and / or pulp of the fruits, in

[1]Submitted on 02/13/2012. Accepted for publication on 10/02/2012.
[2]Laboratório de Sementes, Universidade Estadual do Piauí, 64980-000– Corrente, PI, Brasil.
[3]Centro Nacional de Pesquisa de Hortaliças, Caixa Postal 218, 70359-970– Brasília, DF, Brasil.
[4]Embrapa Uberlândia, 38400-070 – Uberlândia, MG, Brasil.
*Corresponding author <agro_leomara@yahoo.com.br>

wooden or plastic containers for time periods, which depend on the species (George, 2000). This method is very common and has the advantage of being cheap. Other methods, such as immediate washing and fermentation, are commonly used to remove seed mucilage (Vidigal et al., 2006; Meireles et al., 2007). This process has some disadvantages, including the risk of seeds germinating during seed fermentation, seed darkenning, spoiling of their commercial appearance and reduction of the percentage seed germination if the fermentation time is prolonged.

Hydrochloric acid, sodium hydroxide, ammonium hydroxide, sodium carbonate, sulphuric acid, acetic acid, calcium hypochlorite and pectinases can be used during extraction (Brasil, 2009). In this procedure, the product is applied to the seeds, together with the pulp, for recommended time periods and concentrations. Treatment lasts a few minutes and the process is quick and practical. The application of hydrochloric acid in tomatoes did not affect the commercial appearance and quality of the seeds (Amaral and Santos, 1979), but in cucumber seeds, Couto et al. (1969) observed a reduction in seed germination after their extraction from the fruit with hydrochloric acid. The advantage of using chemicals is the faster removal of the mucilage.

The extracted seeds in a wet process led a high water content, demanding special care during the drying process. Drying must be done fast enough to remove the water, which may accelerate destructive metabolism, without harming the seed, caused by the effects of high temperatures and mechanical injury during drying (Marcos-Filho, 2005). Therefore, drying should be done considering the water content which a species needs, or permits, for the conditions in which it will be stored (Carvalho and Nakagawa, 2000).

Few studies have been done on the immediate and latent effects of extraction and drying processes on the seed quality of species with fleshy fruits. The objective of this study was to evaluate the physiological quality of eggplant seeds submitted to different extraction and drying methods.

Material and Methods

A first experiment was carried out to evaluate the influence of the extraction method on the physiological quality of eggplant seeds. The trial was done at Embrapa Vegetables, Brasília, Distrito Federal. Thirty fruits of the eggplant hybrid ‘Ciça’ were harvested in a seed production field. Fruits were harvested 60 days after controlled pollination (brown coloration) and kept for 15 days in a ventilated, dry place until seed extraction. For extraction, fruits were crushed twice in a pepper peeler and the crushed material (pulp + seed) was placed in a plastic container in a ventilated, shaded place for 0, 24 and 48 hours. The pulp of 10 fruits was used for each fermentation period. Water was added to the pulp of five fruits until all the pulp had emerged, separating the fermented tissues from the light seeds of the well-formed seeds, which tend to remain at the bottom of the container (conventional extraction). The pulp of the other five fruits was first cleaned with water and then an 18.5% solution of hydrochloric acid was added for 20 minutes, with the acid volume being the same as that of the seeds. The seeds were then washed again with water.

After each natural fermentation period, and the application or not of acid, the seed moisture content was determined for each treatment, using the oven method at 105 °C ± 3 °C for 24 hours, as described in the Rules for Seed Analysis (Brasil, 2009). After treatment, all the seeds were placed in a pre-drying chamber at 32 °C for 24 hours, followed by oven drying at 38 °C for 24 hours. The dry seeds were tested as follows:

Seed weight: four replications of 100 seeds were weighed on an analytical balance to three decimal places, with the results expressed in grams.

Germination test: four replications of 50 seeds for each treatment were used. The test was done according to the criteria established by the Rules for Seed Testing (Brasil, 2009).

First germination count: done together with the germination test by counting the number of normal seedlings identified on the seventh day after sowing (Brasil, 2009).

Accelerated aging test: this test was done in a gerbox adapted to form a humidity chamber with 76% relative humidity, in which 40 mL of a saline solution (40 g NaCl/100 mL of water) were added. A mesh was suspended in the gerbox, on which each treatment sample was placed to form a single layer of around 250 seeds. The gerboxes were kept for 96 hours in an oven at 41 °C. After this period, the seeds were submitted to the germination test according to the procedure set out in the Rules for Seed Testing (Brasil, 2009), and were evaluated seven days after the start of the germination test.

Seedling emergence in Plantmax® substrate: four replications of 50 seeds were used, sowing them on styrofoam trays of 200 cells with one seed per cell. The trays were kept in a greenhouse and watered as necessary. The number of emerged seedlings was counted 21 days after sowing, when emergence had stabilized.

The experimental design was a completely random 3 (fermentation period) x 2 (hydrochloric acid applied or not) factorial with four replications. The data were transformed into $\sqrt{x}$ and the treatment means were compared using the Tukey test at the 5% probability level (Santana and Ranal, 2004).

The evaluation of the physiological quality of eggplant seeds was done by submitting them to different forms of drying in a second experiment. The seeds were extracted using a pepper peeler, immediately washed in running water and then dried as follows: sun/24 h; sun/48 h; 32 °C (pre-drying chamber)/24 h; 32 °C/48 h; 38 °C (oven)/24 h; 38 °C/48 h; Sun/24 h + 32 °C/24 h; Sun/24 h + 38 °C/24 h and 32 °C/24 h + 38 °C/24 h. The seed moisture content was measured after the different treatments following the same methodology described in the first experiment.

The seeds were evaluated for germination and vigor (first count, accelerated aging and seedling emergence) initially and after six months storage under ambient conditions, following the same methodology used in the first experiment.

The experimental design was completely randomized using four replications. The physiological quality of the seeds was compared using Tukey's test at the 5% probability level (Santana and Ranal, 2004).

Results and Discussion

The analysis of variance of the data from the first experiment gave significant results for the isolated effects of the factors (period of natural fermentation and chemical) in the first count, germination and seedling emergence tests and this interaction was not investigated further (Table 1). There was a significant interaction of the factors for the accelerated aging and seed weight test and this interaction was analyzed further (Table 2).

Table 1. Seed moisture content (SMC) and mean values obtained in the first count (FC), germination (G) and greenhouse seedling emergence tests (SE) for 'Ciça' eggplant seeds submitted to different extraction methods.

Treatment	LM (%)	FC (%)	G (%)	SE (%)
0 h of fermentation + acid	58.98	45 a	90 ab	62 b
0 h of fermentation	67.55	33 a	94 a	87 a
24 h of fermentation + acid	70.03	55 a	91 ab	83 a
24 h of fermentation	70.82	41 a	93 ab	93 a
48 h of fermentation + acid	71.07	43 a	78 b	55 b
48 h of fermentation	74.91	25 a	82 ab	85 a
CV (%)		17.88	4.14	5.64

*Means followed by the same letter in the column do not differ according to the Tukey test at the 5% probability level.

Table 2. Mean values of seed weight and the accelerated aging test on 'Ciça' eggplant seeds extracted from fruits submitted to different fermentation periods (0, 24 and 48 hours), with or without the application of hydrochloric acid after the fermentation period.

Acid Treatment	Weight of 100 seeds (g)			Accelerated aging (%)		
	Fermentation period (hours)			Fermentation period (hours)		
	0	24	48	0	24	48
With	0.507 Ab	0.530 Aa	0.533 Aa	22 Bb	60 Aa	25 Bb
Without	0.565 Aa	0.548 Aa	0.530 Aa	86 Aa	78 ABa	52 Ba
CV (%)		1.8			12.14	

*Means followed by the same capital letter in the row and small letter in the column do not differe according to the Tukey test a t the 5% probability level.

The increase in the fermentation period of the eggplant seeds, independent of the application of acid after fermentation, promoted higher water absorption by the seeds (Table 1). The same result was observed by Lopes et al. (2001) with pomegranate seeds. This hydration demonstrates the absence of any tissue enveloping the integument of the eggplant seed. On the other hand, seeds of "pitomba" (*Talisia esculenta*), which have an aryl, show an opposite hydration behavior during fermentation (Alves et al., 2009), because this process degrades the aryl, reducing the area of contact of the seed for water absorption, resulting in less hydration with a longer hydration period. In the eggplant, fermentation did not degrade any tissues and there was hydration during the fermentation process.

Results from the first germination count showed no significant difference between the seed extraction treatments (Table 1). Fermentation for 48 hours reduced seed germination (Table 1), and this was also observed in purple mangosteen seeds after 72 hours fermentation (Nascimento et al., 2001). This behavior occurred in both species because after these fermentation periods the seeds lacked oxygen (anoxia), resulting in a lower germinative potential, since oxygen is essential for germination. Each species has an ideal fermentation period without causing anoxia: 48 hours for coffee (Araújo et al., 1999), 72 hours for pomegranate (Lopes et al., 2001), 144 hours for yellow passion fruit (Cardoso et al., 2001) and 24 hours for eggplant in the present study.

In the seedling emergence test, the treatments showing a lower vigor were those subjected to 0 and 48 hours fermentation followed by acid application (Table 1). No significant differences were observed for 24 hours fermentation followed by acid application, but in absolute values the acid gave a lower result. Therefore, independently of the fermentation period, seed vigor was maintained, but with the application of acid after each fermentation period there is a reduction in seed vigor as demonstrated in the germination test, where the acid degraded the seed reserves already cleaned during fermentation. This demonstrates that fermentation by itself has no effect on eggplant seed vigor, as has been noted in other species (Candiani et al., 2004; Ono et al., 2004; Alves et al., 2009).

For seed weight (Table 2), there was only a significant difference between those treatments not submitted to fermentation (0 hour), while the treatment with acid application weighed less compared to the untreated treatment, since the former suffered integument degradation by the acid, reducing its area for water absorption and, consequently, showing a lower seed weight.

In the treatments submitted only to natural fermentation in the accelerated aging test, the seeds fermented for 0 and 24 hours were not less vigorous, but fermenting them for 48 hours reduced the seed quality (Table 2). This reduction in vigor may have occurred due to the anoxia observed in germination (Table 1), probably affecting the seeds at germination; also the recovery of tissues degraded by the stress caused to the seed due to lack of oxygen, thereby reducing seed vigor. However, seeds submitted to acid with a previous 24 hours fermentation were more vigorous compared to 0 and 48 hours periods of fermentation (Table 2); as seen in the results for the emergence test, the high vigor in absolute values at 24 hours was still low compared to values for seeds untreated with acid after fermentation.

In the present study, the acid treated seeds had their physiological quality reduced independent of the fermentation period and fermentation for 48 hours also reduced the physiological quality of eggplant seeds. Similar results were observed in coffee seeds (Araújo et al., 1999), whereas the physiological quality of yellow passion fruit (Cardoso et al., 2001) and pitomba (Alves et al., 2009) seeds increased after fermentation.

The different methods of seed drying resulted in various levels of moisture content in seeds, with some types causing a greater reduction in moisture content than others (Figure 1). This reduction was greater for the following drying methods: sun/48 h; 38 °C/24 h; 38 °C/48 h; sun/24 h + 38 °C/24 h and 32 °C/24 h + 38 °C/24 h, which had around 4% moisture content. The moisture content for the other drying methods was a maximum 6% (Figure 1). Thus, all the drying methods used were efficient, resulting in a suitable moisture content for storing eggplant seeds in impermeable containers, a maximum of 6% according to George (2000).

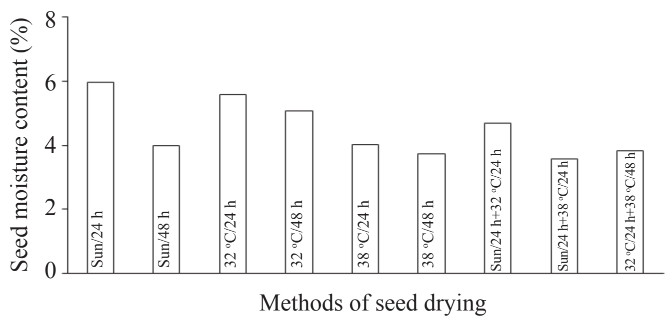

Figure 1. Seed moisture content of 'Ciça' eggplant seeds submitted to different methos of drying.

With the exception of the seedling emergence test in the field, the different drying methods did not cause any negative effect on seed physiological quality (Table 3). Fast or excessive drying can significantly reduce seed viability (Marcos-Filho, 2005) but drying did not negatively affect seed physiological quality in this study (Table 3).

However, the negative effect of drying may be observed soon after the operation (immediate effect) or only during storage (latent effect). Araújo et al. (2000) observed a latent effect in sweet corn seed caused by drying at 40 °C and 50 and 60% relative humidity. However, in the present study, the seed quality after six months storage was unaffected by the drying methods used (Table 3). There were no treatment differences in the seedling emergence test after seed storage in contrast to results obtained from recently-harvested seeds (Table 3).

Based on the results of the present study, eggplant seeds may be dried using various methods, which do not affect their physiological quality immediately after drying or after a storage period.

Table 3. Means values of germination and seedling emergence of eggplant seeds submitted to different methods of drying and stored (SA) or not stored (SNA) for six months.

Methods of seed drying	Germination (%)		Seedling emergence (%)	
	SNA	SA	SNA	SA
Sun / 24 h	98 a	100 a	89 ab	100 a
Sun / 48 h	100 a	100 a	90 ab	97 a
32 °C / 24 h	99 a	100 a	95 a	100 a
32 °C / 48 h	100 a	100 a	93 a	96 a
38 °C / 24 h	99 a	100 a	89 ab	100 a
38 °C / 48 h	100 a	100 a	77 b	100 a
Sun / 24 h + 38 °C / 24 h	99 a	100 a	97 a	100 a
Sun / 24 h + 38 °C / 24 h	99 a	99 a	94 a	99 a
32 °C / 24 h + 38 °C / 24 h	99 a	99 a	96 a	94 a
CV (%)	0.84	0.47	7.34	2.98

* Means followed by the same letter in the column do not differ between themselves according to the Tukey test at the 5% probability level.

Conclusions

Eggplant seeds do not need to be fermented during extraction.

Fermentation with hydrochloric acid reduces the physiological quality of eggplant seeds.

All the drying methods used in this study could reduce seed moisture content for storage and maintained seed physiological quality.

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