

DRYING PEANUT SEED USING AIR AMBIENT TEMPERATURE AT LOW RELATIVE HUMIDITY¹

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ABSTRACT - The moisture content of peanut kernel (*Arachis hypogaea* L.) at digging ranges from 30 to 50% on a wet basis (w.b.). The seed moisture content must be reduced to 10.5% or below before seeds can be graded and marketed. After digging, peanuts are cured on a window sill for two to five days then mechanically separated from the vine. Heated air is used to further dry the peanuts from approximately 18 to 10% moisture content w.b. Drying is required to maintain peanut seed and grain quality. Traditional dryers pass a high temperature and high humidity air stream through the seed mass. The drying time is long because the system is inefficient and the high temperature increases the risk of thermal damage to the kernels. New technology identified as heat pipe technology (HPT) is available and has the unique feature of removing the moisture from the air stream before it is heated and passed through the seed. A study was conducted to evaluate the performance of the HPT system in drying peanut seed. The seeds inside the shells were dried from 17.4 to 7.3% in 14 hours and 11 minutes, with a rate of moisture removal of 0.71% mc per hour. This drying process caused no reduction in seed quality as measured by the standard germination, accelerated ageing and field emergence tests. It was concluded that the HPT system is a promising technology for drying peanut seed when efficiency and maintenance of physiological quality are desired.

Index terms: *Arachis hypogaea*, quality, vigor, germination, conditioning.

SECAGEM DE SEMENTES DE AMENDOIM COM AR À TEMPERATURA AMBIENTE E BAIXA UMIDADE RELATIVA

RESUMO - O grau de umidade da semente de amendoim no momento do arranquio da planta varia de 30 a 50% em base úmida (b.u.). Após o arranquio, as plantas são secadas em média por dois a cinco dias, quando, então, as vagens são separadas mecanicamente das plantas. Na seqüência, ar aquecido é utilizado para secar a semente de amendoim na vagem a 10,5% de umidade b.u. ou menos, antes de ser classificada, armazenada e comercializada. A secagem é requerida para manter a qualidade da semente e do grão de amendoim. Secadores tradicionais operam com fluxo de ar com altas temperatura e umidade relativa, através da massa de sementes. O período de secagem é longo porque o sistema tradicional de secagem é ineficiente e a alta temperatura aumenta o risco de dano térmico à semente. Nova tecnologia, identificada como “heat pipe technology” (HPT), está disponível e tem como característica remover a umidade do ar antes dele ser aquecido e passado através da massa de sementes. No presente estudo sementes dentro das vagens foram secadas de 17,4 para 7,3% de umidade b.u. em 14 horas e 11 minutos, com taxa de remoção da umidade de 0,71% por hora de secagem. O processo de secagem “HPT” não causou redução na qualidade fisiológica da semente, avaliada pelos testes de germinação, envelhecimento acelerado e emergência no campo. Concluiu-se que o sistema “HPT” é uma tecnologia promissora para a secagem da semente de amendoim, principalmente quando eficiência e manutenção da qualidade fisiológica são requeridas.

Termos para indexação: *Arachis hypogaea*, qualidade, vigor, germinação, condicionamento.

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INTRODUCTION

The moisture content of the peanut kernel at harvest ranges from 30 to 50% on a wet basis (w.b.). After digging, peanuts are partially cured on a window sill for two to five days then mechanically separated from the vine. Heated air is used to further dry the peanuts from approximately 18 to 10% w.b. moisture content (Bader et al., 1996).

Drying is one of the most critical operations in maintaining peanut seed quality because the peanut seed coat differs from other leguminous plants. There is no palisade thick walled cell layer and no hourglass cell. The tissue is not differentiated (Corner, 1951). The water exchange between the seed and the environment is mediated by the integument (Ketring et al., 1976) and is a barrier to fungi infection (Zambettakis, 1975).

High temperature during peanut drying causes detachment of the seed coat, allowing the cotyledons to separate, which is referred to by the industry as splitting (Wright and Steele, 1979). Splitting reduces the value of peanuts. Most crop seeds are dried at temperatures of 35°C for high moisture (above 25%) and 40 to 43°C for lower moisture without germination reduction in case of maize (Baker et al., 1991). Temperature and drying rate are factors in drying injury (Herter and Burris, 1989). Drying damage, as evidenced by a reduction in seed physiological quality, frequently occurs and it is not certain whether high temperatures or high drying rates cause the injury (Burris and Navratil, 1980).

The medium used in drying is ambient air, which over time and location varies in moisture content. In a drying operation the air carries heat into the system to evaporate moisture and then carries the evaporated water out of the system (Brooker et al., 1974). This method is inefficient as the hot air contains large quantities of moisture and the high temperature required is detrimental to seed quality. In this system the air flow rate must be sufficient to avoid saturation before it leaves the seed mass. The air flow rate can be increased until it is capable of absorbing the moisture released by the seeds (Boyd et al., 1975). The seed drying speed is also determined by the rate at which the moisture migrates from inside to the outmost layer of the seed and then through the hull (Brandenburg et al., 1961).

When drying with hot air, the temperature range of 40.5 to 43.3°C is the maximum tolerated by seeds without causing physical and chemical damage (Brooker et al., 1974). The combination of high temperature, low relative humidity and high air flow rate is detrimental to the physiological quality of

the seeds (Esdras, 1993). Moist seeds are more susceptible to thermal damage; so the higher the seed moisture content the lower should be the drying temperature (Harrington, 1972). It is normally accepted that seeds with more than 18% moisture should be dried at 32°C and those with lower moisture content can be dried at 38°C. Drying temperature should be adjusted according to the relative humidity of the drying air (França Neto et al., 1994).

New technology is available and a prototype dryer has been developed that has the unique feature of taking the moisture out of the air stream before it is heated and passed through the seed mass. The heat generated when the water is removed is reintroduced into the air stream and raises the air temperature. In contrast to the 40°C temperature required by conventional bin dryers, the temperature of the air stream in the new technology never exceeds 32°C. The purpose of this research was to evaluate the potential of this new technology for drying peanut seed. The evaluation included measuring the capability of the prototype to deliver temperatures and air flows suitable for efficient and safe drying. The effect of drying on the physical and physiological qualities of peanut seed was evaluated.

MATERIAL AND METHODS

Peanut seed from the runner market type cultivar SunOleic 7R, runner type, was harvested at the Florida Foundation Seed Producers Inc. facility at Greenwood, FL. The seed moisture content (mc) at harvest was 17.4% fresh weight. An electrical moisture tester (Dole 400) was used to determine the mc, which was further checked by using the oven test, as prescribed by AOSA (1987). In this trial 34kg of seed was dumped into the bin of the dryer prototype (Figure 1). The seed batch depth was 25cm. An airflow rate of 8m³.minute⁻¹.t⁻¹ of seed volume was maintained, based on the recommendation of Matthes and Rushing (1972).

The prototype dryer utilised the “heat pipe technology”, as a source of dry air at ambient temperature, and consisted of a special dehumidification air conditioner. The heat pipes increased the dehumidification efficiency of vapour compression in the air conditioning process. The system relied on two technologies to dry the air and extract heat from the moist air. Dehumidifier heat pipes produced dry air, and a latent heat pump produced low cost heat energy from the ambient air (Dinh, 2000) (Figure 2).

Based on peanut drying preliminary studies, the sampling procedures for the physiological quality evaluation were

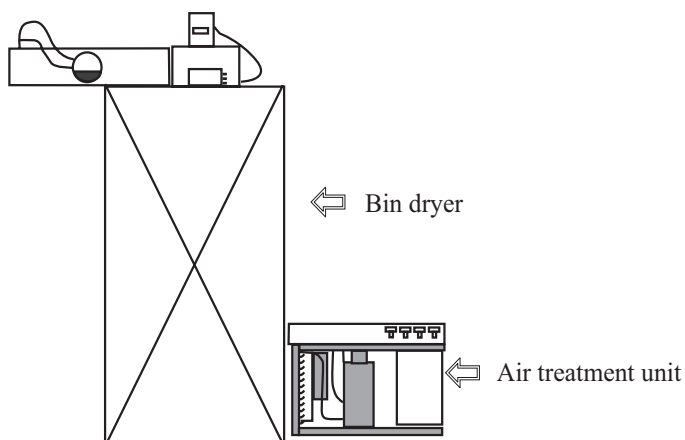
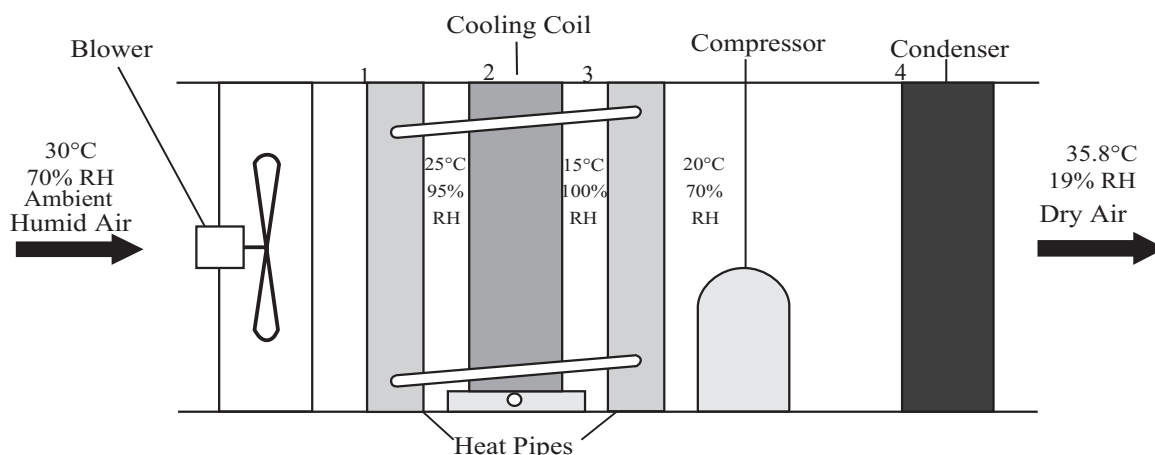


FIGURE 1. Dryer prototype used for the drying trial.

designed to follow the same procedures adopted in the seed industry. Samples to evaluate seed quality were taken at the beginning and at the end of the drying operation. Seed moisture content was monitored during the process until it reached 7.30%. One kilogram samples were withdrawn by hand throughout the seed batch depth at each sampling time. The peanut samples were shelled by hand and the seeds were homogenised. The seed samples were sealed in plastic bags and stored in a room at 10°C for 24 hours.

A series of seed quality tests consisting of the standard germination test (SGT), accelerated ageing test (AAT) and field emergence test were performed on all samples taken at the beginning and at the end of the drying trial.

The SGT and AAT were performed as prescribed by



Electric Heat Pump with Dehumidifier

FIGURE 2. Air treatment and examples of typical temperatures and relative humidity at various stages before passing through the seed mass. 1- Pre cool; 2 - Evaporator; 3 - Re-heat and 4 - Condenser.

AOSA (1987) and (1983) respectively. The field emergence trial was performed inside a screen house using field soil, where 400 seeds were sown in 8 one meter long rows 1 and 10cm apart with 50 seeds each row. The final count was made on the 20th day after sowing. The seedbed was irrigated daily as needed. To break dormancy all seeds used in the quality tests were treated with ethrel. The experimental design consisted of a completely randomised design with four replications, each one composed of four sub-samples each for SGT and AAT, with 50 seeds each. Four replications of 100 seeds each were used for the field emergence trial.

RESULTS AND DISCUSSION

Peanut seed in a deeper seed layer (25cm) was dried from 17.4 to 7.3% in 14 hours and 11 minutes; a moisture

content removal rate of 0.71% per hour, which was faster than 0.45% per hour observed by Butts and Omary (1999) working with a traditional drying system (39.1°C and 33% RH). The temperature data of the air through the heat pipe system, the temperature and the relative humidity of the air that passed through the dryer bin are shown in Tables 1 and 2. The drying was achieved with a 25cm deep seed layer, using an air flow rate of $8\text{m}^3 \cdot \text{minute}^{-1} \cdot \text{t}^{-1}$ of seed volume at an average temperature of 34.6°C and 27% relative humidity. The drying rate of 0.3% of water removal per hour with hot air at 43°C and an air flow rate of $5.5\text{m}^3 \cdot \text{minute}^{-1} \cdot \text{t}^{-1}$ of seed is a general rule to be followed in a seed drying process (Brandenburg et al., 1961), which is less efficient than the 0.71% observed in the present experiment.

The combination of average drying conditions of 34.6°C temperature and 27% relative humidity were very effective in

TABLE 1. Air temperature of ambient and inside the heat pipe system.

Time	Temperature (°C)				
	Ambient	Pre-Cool	Evaporator	Re-Heat	Condenser
09:44AM	23.8	21.1	20.5	21.1	23.3
10:16AM	25.0	18.8	10.0	14.4	32.2
03:35PM	37.2	23.3	14.4	19.4	37.2
09:25PM	30.0	23.3	12.2	17.7	35.0
STOP DRYING – RE-STARTED NEXT DAY					
12:05PM	31.0	23.3	12.2	17.7	39.4
02:30PM	31.6	23.3	11.1	19.4	38.8

TABLE 2. Air temperature and relative humidity (RH) conditions inside the bin.

Time	Plenum		Seed Depth Level - T C			Bin Top	
	T C	RH (%)	Floor	10cm	20cm	T C	RH (%)
09:44AM	23.3	37	23.3	23.3	23.3	23.3	56
10:16AM	32.2	28	32.2	31.6	27.7	23.8	50
03:31PM	37.2	23	37.0	37.0	36.6	32.2	31
09:25PM	36.6	22	36.6	36.1	36.1	32.7	28
STOP DRYING – RE-STARTED NEXT DAY							
12:05PM	39.4	27	39.4	38.8	38.3	32.2	38
02:30PM	38.8	26	38.8	38.8	38.8	32.7	34

drying peanut. There was no loss of seed coat colour and darkening of the cotyledons, as have been observed in drying procedures with heated air when the air temperature goes up to 75°C in the traditional trailer dryer operation (Travaglini and Tango, 1966). In contrast, no detachment and rupture of the seed coat were observed. A rate of 33% seed coat detachment was observed in kernels near the air entrance in the intermittent peanut hot air drying system as reported by Troeger and Butler (1980).

The physiological quality of the peanut seed was maintained by the new technology dryer. Drying with low temperature and relative humidity at recommended air flow rate did not reduce the vigour based on the AA and field emergence tests (Table 3). Dey et al. (1999) observed that slow drying or low temperature/low humidity drying reduced

physical damage and maintained high vigor and viability during storage. The maximum recommended plenum temperature is 35°C and the minimum plenum humidity is approximately 50% (Cundiff et al., 1991). Penuela (1979) reported a decrease from 37.99 to 22.49% in peanut seed vigour index based on germination speed, when the drying temperature was increased from 43.33 to 104.44°C in a hot air drying system. A slight increase in germination percentage from 82 to 89% was observed which could be attributed to seed pathogen control due to the HPT drying process. The seeds after drying produced no abnormal seedlings due to fungi infection as observed in the test with wet seeds. Butts and Omary (1999) dried peanut seed at 34.1°C and 40% RH and obtained germination value of 76% which was 13% less than observed using the HPT dryer system.

TABLE 3. Peanut seed physiological quality before and after the drying period.

Drying	Seed Moisture (%)	Germination (%)	Accelerated Ageing Test (%)	Field Emergence (%)
Before	17.4	82 a ¹	74 a	82 a
After	7.3	89 b	76 a	79 a
C.V.		1.78 %	3.46 %	4.23 %

¹Means followed by same letter in a column do not differ statistically according to the Duncan's multiple range test at 5.0% probability.

CONCLUSION

Peanut seed drying provided by the heat pipe technology is an efficient process and caused no detrimental effects on seed physiological quality.

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