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Peanut Drying Energy Consumption

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ABSTRACT

Total energy consumption and drying times were determined for drying peanuts with various equipment and procedures commonly used by the peanut industry. Total peanut drying times were significantly shorter with 3.73 kW, single-trailer (ST) dryers than with 7.46 kW, double-trailer (DT) dryers. Total energy consumption was significantly higher per tonne of peanuts dried for drying with ST dryers. Total energy consumption and drying times were not significantly different for drying in side-air-entry or rear-air-entry trailers. Precleaning reduced energy requirements for drying and slightly reduced total drying times. Drying peanuts at 40.56°C decreased drying times but required considerably more energy than drying at 35°C. Type of temperature control, constant (Co) or cycling (Cy), had no effect on drying times or energy consumption.

Key Words: peanuts, drying, energy consumption, cleaning.

This study was conducted in 1975 and 1976 at a peanut drying, cleaning and receiving station owned by Stevens Industries, Inc. at Parrott, Georgia.

The purpose was to determine and compare differences in drying times and energy consumption during peanut drying with the following full-scale, conventional equipment and procedures:

a. 3.73 kW, single trailer (ST) and 7.46 kW, double trailer (DT) propane gas-fired dryers.
b. Trailers with side-air-entry (SAE) and trailers with rear-air-entry (RAE).
c. Precleaned (C) and uncleaned (Uc) peanuts.
d. Two average drying air temperatures: 35°C (L) and 40.56°C (H).
e. Two types of temperature control: one with a continuously operating burner (Co) and one with a repetitively cycling burner (Cy) on 50%, off 50% of the time (each cycle less than one minute).

Materials and Methods

Three different experiments were conducted during two drying seasons to determine the objectives; Experiment 1 in 1975, Experiments 2 and 3 in 1976.

Florunner peanuts for each replication of eight treatments in each experiment were removed from the soil during one day and placed in windrows with invertors for partial drying. After windrow drying for 1 to 7 days, 32.7 to 36.3 tonnes of peanuts were harvested by combine during an afternoon and used to evenly fill eight, 4.3 m x 2.4 m x 1.4 m Peerless[3] (4-RAE and 4-SAE) drying trailers for transportation to the drying facility and subsequent artificial drying. Four Model 153, 3.73 kW ST and two Model 103, 7.46 kW DT Peerless, propane gas-fired dryers were used for drying the peanuts of each replication. The 3.73 kW dryers had a manufacturer's rated airflow rate of 305.6 cubic meters per minute (m^3/min) under 2.54 cm of water static load; the 7.46 kW dryers had a rate of 475.8 m^3/min. Watt hour meters were used to measure electricity used by each dryer. Gas consumption was determined from weight loss of individual propane tanks for each dryer. Initial and final moisture contents of the peanuts were determined by oven drying 250 g of shelled kernels at 130°C for 3 h and calculating moisture content based on weight loss. Moisture samples were taken with a standard farmers stock sample probe. Start-up time for treatments of a replication varied less than 5 min. Artificial drying was discontinued when the moisture content (m.c.) of the peanuts reached 11-12%.

1975 Experiments

The effects of dryer type (ST, DT), plenum air entry (SAE, RAE), and peanut precleaning (C, Uc) on total drying time and energy consumption were investigated in Experiment 1 in 1975. The drying air temperature (35°C or lower, 11.11°C maximum heat rise from ambient temperature) was controlled with cycling-type flame controls on each dryer. The burner flame was operated with an on-off thermostat set at the desired temperature. Gas pressure was controlled manually at each dryer and adjusted as ambient temperature changed to maintain flame operation 50% of dryer operation time. Plenum temperature next to the plenum wall directly opposite the air entry was measured and recorded. Peanuts of four of the eight tests for each of the eight replications in Experiment 1 were precleaned at the drying facility with a commercial precleaner before drying.

1976 Experiments

Two types of temperature controls were studied in 1976 in Experiment 2, Co and Cy. Average plenum temperature was controlled at 35°C (or lower 11.11°C maximum temperature rise above ambient temperature) for all treatments of each of the four replications. A cycling flame maintained an average temperature on four of the tests as described in Experiment 1. A constant temperature was maintained on the other four treatments by manually regulating gas pressure to the burners at a level low enough to prevent burner cycling but high enough to maintain the desired average temperature. None of the peanuts for these tests were precleaned.

Two drying air temperatures, 35°C (or ambient temperature plus 8.33°C) and 40.56°C (or ambient temperature plus 13.89°C) were studied in 1976 in Experiment 3. Cycling-type temperature controls were used for controlling the average temperature of both groups of four treatments of each of the four replications. Peanuts were not precleaned.

Results and Discussion

Peanuts for Experiment 1 ranged in initial m.c. from 13 to 31%. For Experiments 2 and 3, peanut initial m.c. ranged from 23 to 25%. Initial m.c. variation between treatments of each replication had no significant effect on the results in any of the experiments. Final moisture contents of the peanuts were 11.4, 11.5, and 11.6 for Experiments 1, 2, and 3, respectively. No significant differences in the measured test responses

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were produced by variations in dryer performance within each type of dryer. Initial weight variations of the treatments of each replication had no significant effect on the measured results. Final weights of the treatments of each replication generally varied less than initial weights.

Single Trailer and Double Trailer Dryers

An analysis of variance revealed significantly less total drying times for peanuts dried with 3.73 kW, ST dryers than for peanuts dried with 7.46 kW, DT dryers. The major difference between the ST and DT dryers used was that the ST dryers supplied a higher volume of airflow per unit volume of peanuts than the DT dryers. Based on the manufacturer's airflow rating, the ST dryers supplied 21 $m^3/min/m^3$ of peanuts; DT supplied 16.7 $m^3/min/m^3$ of peanuts. The airflows of the dryers were not measured during the tests; however, the differences in drying times indicate that airflow rates did differ (2).

The effects of initial m.c. on the total drying times for ST and DT dryers are shown in Figure 1. The regression equations predicted a 3.5-hour longer total drying time for drying 32% initial m.c. peanuts with DT dryers than with ST dryers; for 20% initial m.c. peanuts, drying time was 1.2 hours longer.

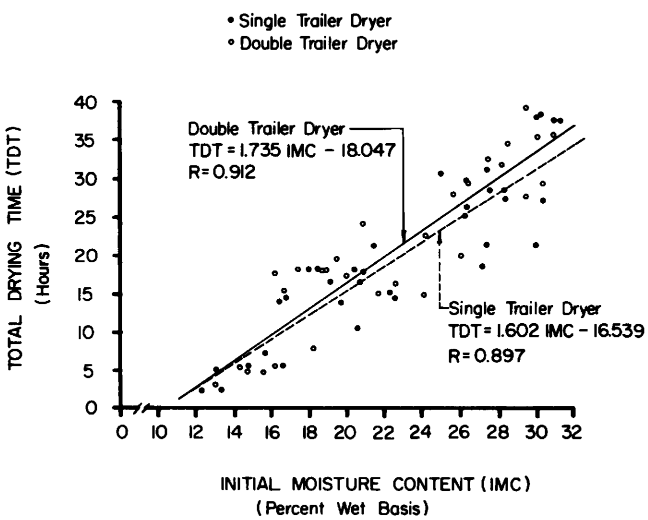

Fig. 1. The effect of initial m.c. on total drying times of peanuts dried with ST and DT dryers.

Electricity requirements per tonne of peanuts dried were not significantly different for ST and DT dryers. The relationship between initial m.c. and total electricity used per tonne of peanuts dried is shown in Figure 2. Peanuts with 13% m.c. required 5.67 kilowatt hours (kW.h) per tonne for drying; those with 31% required 37.8 kW.h per tonne.

Gas requirements per tonne of peanuts dried were significantly different for ST and DT dryers. The higher gas requirement per tonne, i.e. heat requirement, for ST dryers indicates a higher airflow per unit volume of peanuts than for DT dryers. Regressions of gas required for both types of dryers on initial m.c. are shown

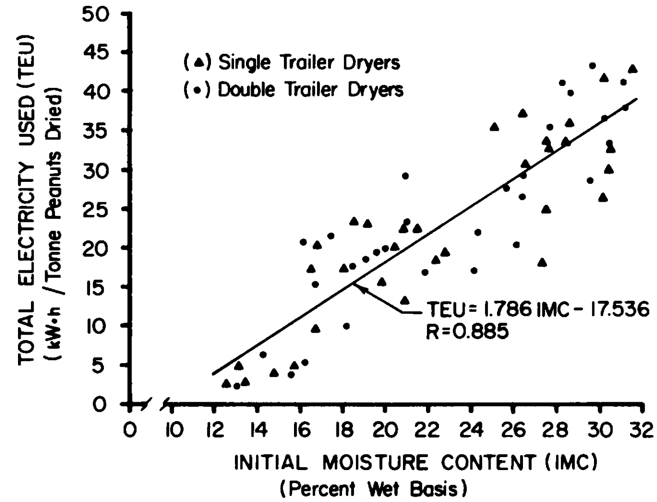

Fig. 2. The effect of initial m.c. on total electricity used for drying peanuts with ST and DT dryers.

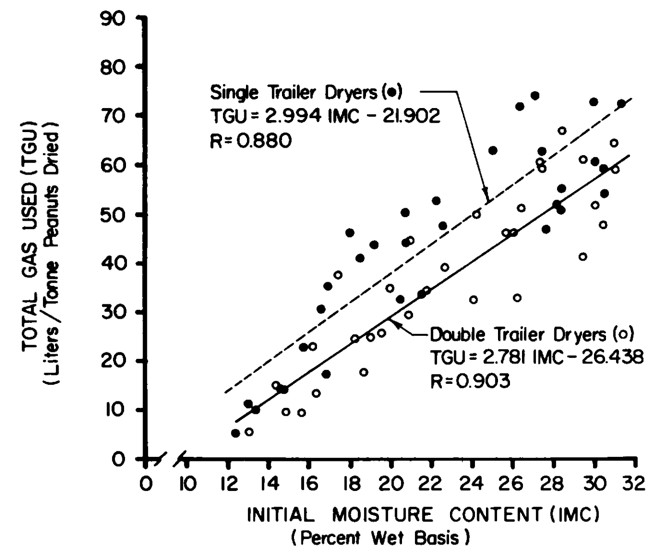

Fig. 3. Comparison of the effects of initial m.c. on total gas used during drying with ST and DT dryers.

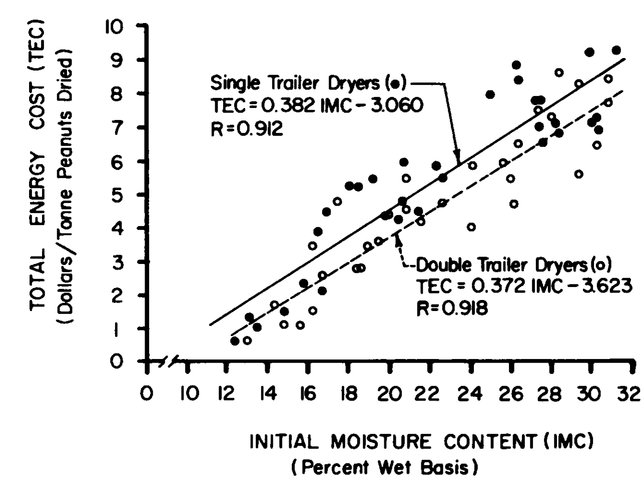

Fig. 4. Comparison of the effects of initial m.c. on total energy costs for drying with ST and DT dryers.

in Figure 3. ST dryers required about 7.3 L per tonne more gas than DT dryers for drying peanuts with a

13% initial m.c. and 11.1 L per tonne more for 31% initial m.c. peanuts.

Total energy costs for ST and DT dryers are compared in Figure 4. Gas costs were calculated at 8.72 cents per L and electricity at 7 cents per kW.h. Variation in total energy costs between the dryers ranged from 70.5 cents per tonne of peanuts dried from a 13% initial m.c. to 90.3 cents per tonne for those dried from a 31% initial m.c.

Average hourly energy costs per trailer for the dryers during the 6-week drying season of these tests are shown below:

Type dryer	Average hourly energy costs per trailer	Standard deviation
	Dollars	Dollars
ST	1.27	0.26
DT	0.92	0.18

Operating DT dryers with only one load of peanuts would negate the cost advantage of this type of dryer as compared to ST dryers.

Side-Air-Entry and Rear-Air-Entry Trailers

No significant differences in total drying times or electricity and gas requirements were found for drying peanuts in SAE or RAE trailers.

Precleaned and Uncleaned Peanuts

Electricity and gas requirements and total drying times were significantly different for drying cleaned and uncleaned peanuts. The effect of initial m.c. on these three parameters are shown in Figures 5, 6, and 7, respectively. Variation in total cost decreased from 58 cents per tonne for peanuts with 31% initial m.c. to 1.7 cents per tonne for 13% initial m.c. peanuts (Fig. 8).

All peanuts used for these tests contained less than 10% foreign material after combining with small amounts of loose soil. Cleaning peanuts with large percentages of loose soil or small rocks would probably produce more pronounced differences in both drying rates and energy consumption than our results showed. Cleaning costs are generally much higher, however, than the energy savings obtained for the cleaned peanuts dried in these tests.

Drying Air Temperature

The effects of drying air temperature on total drying time, total gas and electricity used per tonne of peanuts dried, and total energy costs per tonne of peanuts dried are shown in Table 1. Peanuts dried with the low temperature required an average of 3.8 hours longer for drying than for drying with the high temperature; consequently, 3.3 kW.h per tonne of peanuts more electricity were required for the low temperature peanuts. Total gas used per tonne, however, averaged 13.2 L more for the high temperature, making total energy costs about $1.05 per tonne higher for drying with the high temperature. In addition to the increased

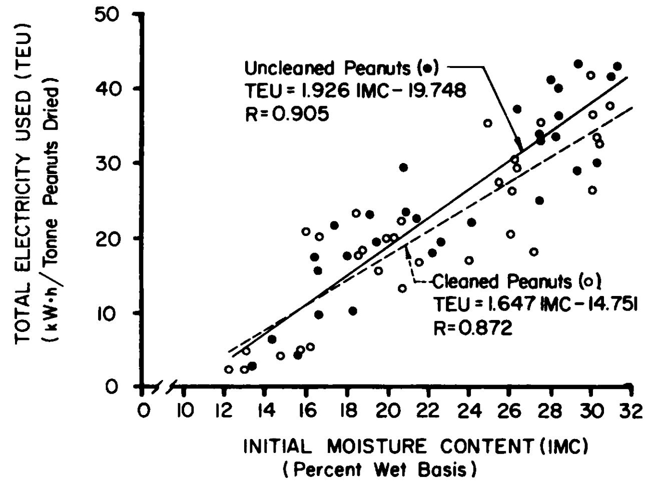

Fig. 5. Comparison of the effects of initial m.c. on total electricity used for drying Uc and C peanuts.

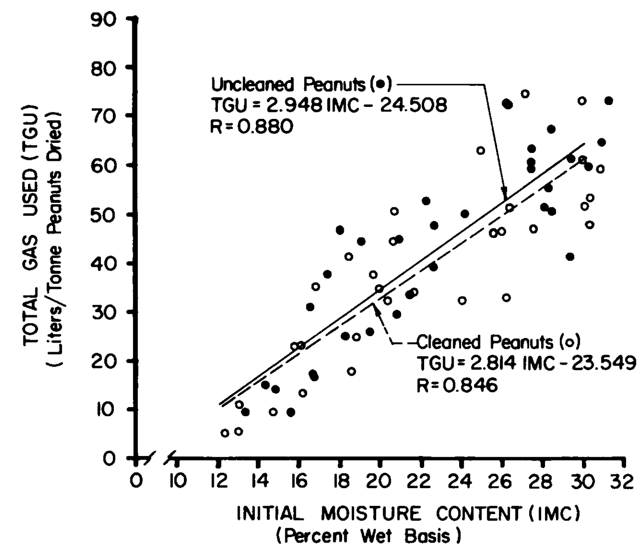

Fig. 6. Comparison of the effects of initial m.c. on total gas used for drying Uc and C peanuts.

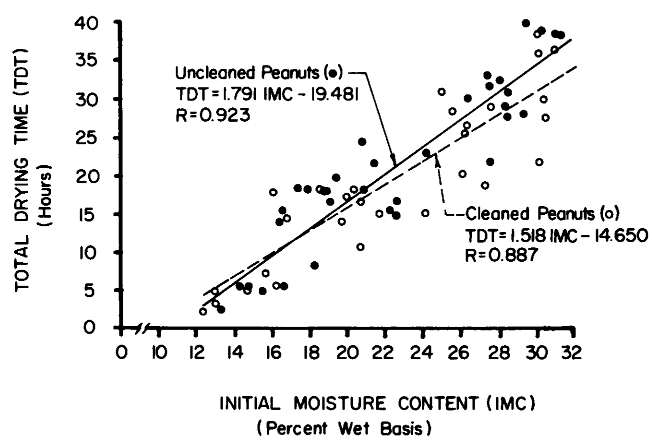

Fig. 7. Comparison of the effects of initial m.c. on total drying times for drying Uc and C peanuts.

costs, drying peanuts with high temperatures has a detrimental effect on peanut milling quality (1).

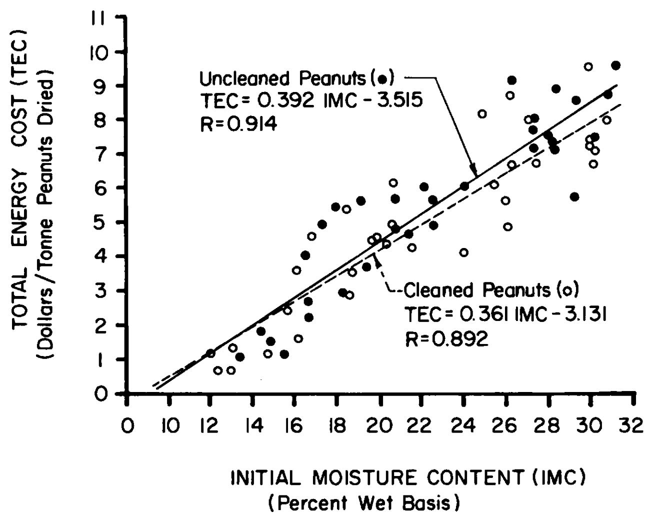

Fig. 8. Comparison to total energy costs for drying Uc and C peanuts.

Table 1. Comparison of the effects of drying temperature on total drying time, total electricity used, total gas used, and total energy cost.

Measured Parameter	Low 1/	High 1/
Total drying time	19.8 hrs	16.0 hrs
Total electricity used	22.1 kW•h/tonne peanuts dried	18.8 kW•h/tonne peanuts dried
Total gas used	38.7 L/tonne peanuts dried	53.58 L/tonne peanuts dried
Total energy cost per tonne	4.91 dollars/tonne peanuts dried	5.97 dollars/tonne peanuts dried

1/ Average of ST and DT readings.

Constant and Cycling Temperatures

No significant differences were observed in total drying time or total gas or electricity used for drying peanuts at the same average plenum temperature with Co or Cy temperature controls.

Conclusions

1. Total drying times were longer for drying with double trailer dryers than with single trailer dryers because the double trailer dryers supplies a lower airflow rate per unit volume of peanuts than the single trailer dryers. Electricity requirements per tonne of peanuts dried were not different for single trailer and double trailer dryers, but gas requirements and total energy costs were higher for the single trailer dryers.

2. Total energy requirements and total drying times were not different for drying in side-air-entry or rear-air-entry trailers.

3. Total drying times were shorter for drying precleaned peanuts than for uncleaned peanuts that contained less than 10% foreign material initially. Gas and electricity requirements and total energy costs per tonne of peanuts dried were slightly higher for uncleaned peanuts.

4. Drying peanuts with 40.56°C air required more gas but less electricity than drying with 35°C air. Total energy costs were higher for drying with the high temperature, even though total drying times were shorter.

5. Type of temperature control, constant or cycling, had no effect on the parameters measured.

Acknowledgements

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