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Air Flotation Velocities and Physical Properties of Peanuts and Foreign Materials

Paul D. Blankenship[1] and E. Jay Williams[2]

ABSTRACT

Physical properties of size, thickness, length, specific gravity, and flotation velocity were determined for various separations of peanut pods, kernels, and foreign materials. Pods had overall thicknesses large enough to allow removal of an average of 22% of the raisins and 32% of the rocks from the pods by screening. More than 96% of the peanut vines, weed stalks, and taproots were over 1 in long. Rocks and soil clods has specific gravities 2 to 4 times greater than pods. Flotation velocities for all of the materials varied from 100 to 3000 ft/min with most of the materials having velocities of 1000 to 2700 ft/min.

Key words: Flotation-Velocity, Foreign-Materials, Peanuts, Cleaning, Physical-Properties, Specific-Gravity.

Excessive amounts of foreign material in farmers' stock peanuts continue to be a problem to the peanut industry. From 1971-75 the average amount of foreign material in farmer's stock peanuts ranged from 4.0 to 5.1% depending upon market type and growing area (7). According to the marketing agreement, peanuts with 10% or more foreign material must be precleaned prior to being marketed. However, peanuts with foreign material of less than 10% are usually not precleaned and the foreign materials occupy valuable space in storage and provide an ideal environment for mold and insect infestation. Removal of all foreign material is practically impossible with one pass through conventional precleaning machinery. Some of the materials that are troublesome to remove, such as immature peanuts (raisins), horsenettle berries, nutsedge tubers, and short sticks will eventually accumulate in the secondary circuits of shelling plants (3).

Different physical and aerodynamic properties are utilized in making separations between peanuts and foreign materials. Separations are made difficult by both the variability and the similarity of the physical and aerodynamic properties of foreign materials and peanuts. Separations are further hindered by the changing of weights and physical size of the materials with environmental changes.

Flotation velocities have been determined for some separations of peanuts and foreign materials (2,4,5,6). Those reported by Williams and Butler (6) were determined for peanut components before and after peanuts were dried. Some varieties of peanuts in the reported research are no longer grown extensively and have been replaced by other varieties (4,5). The flotation velocity of many troublesome materials has never been determined.

The purpose of this research was to determine physical properties and flotation velocities for various separations of peanut components and foreign materials commonly found prior to shelling, and to determine flotation velocities for foreign materials previously unavailable. This information should facilitate adjustment of conventional precleaning equipment and design of more effective precleaning systems.

[1]Agricultural engineer, U.S. Department of Agriculture, Agricultural Research Service, Georgia-South Carolina Area, National Peanut Research Laboratory, Dawson, Georgia 31742.

[2]Agricultural engineer, U.S. Department of Agriculture, Agricultural Research Service, Georgia-South Carolina Area, Georgia Coastal Plain Experiment Station, Tifton, Georgia 31794.

Materials and Methods

Our research was conducted in 1975 at the National Peanut Research Laboratory in Dawson, Georgia, and at the Harvesting, Processing, and Storage Research Facilities, Georgia Coastal Plain Experiment Station, Tifton, Georgia. Small lots (10 to 20 lb) of farmers' stock Spanish-, Runner-, and Virginia-type peanuts, including foreign materials, were collected from marketing locations in the Southeast and the Virginia-Carolina areas from the 1974 crop. The peanuts in all of the lots were stored for 5 months prior to the tests.

Each lot was graded according to the standards of the Federal-State Inspection Service and then separated by market type into various categories. The samples of peanut pods, raisins, and rocks were further divided into subsamples by maximum diameter or thickness by being passed over screens with slots 3/4 in. long and 16/64, 18/64, 22/64, 26/64, 30/64, 34/64, and 38/64 in. wide. Cumulative thickness distributions by weight were determined for the pods, raisins, and rocks.

Loose shelled kernels (LSK) were further separated into subsamples of split, whole, and oil stock kernels (broken and whole kernels having thicknesses of less than 16/64 in.).

Other foreign material categories included peanut stems, leaves, vines, taproots, weed stalks, soil, soil clods, rocks, corncobs, nutsedge tubers, horsenettle berries, wild cucumbers, and maypops (passion flower fruit). Broken peanut vines, weed stalks, and taproots of peanuts and weeds were separated by type and length. Frequency distributions by number were then determined.

The specific gravity of several of the materials was determined by weighing and measuring mercury displacement upon immersion. Ten specimens selected from typical samples of each material were tested.

Flotation velocities were determined for all of the subsamples of materials from each lot except for soil and rocks.

A schematic drawing of the equipment used to determine flotation velocity is shown in Fig. 1. The equipment consisted of a variable speed fan, a 12-ft vertical section of 11.944-in. inside diameter (ID) pipe attached to fan outlet, and a 20-ft horizontal section of 11.944-in. ID pipe attached to the fan inlet. An 11.5-in.

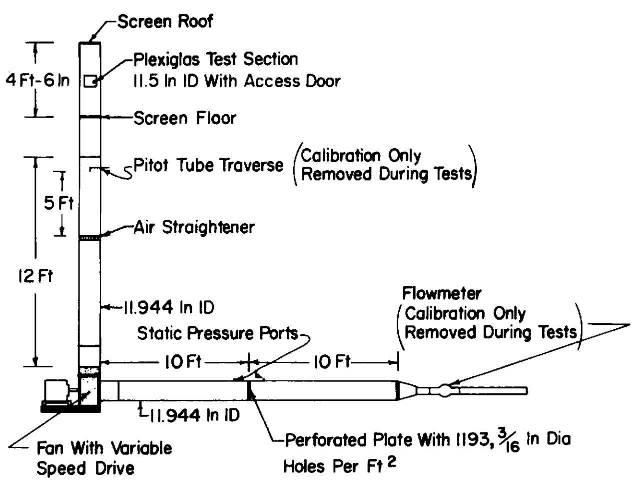

Fig. 1. Schematic drawing of test equipment for determining flotation velocities.

ID, 4.5-ft-long plexiglas test chamber with access door, screen floor, and screen roof was attached to the top of the vertical pipe. The static pressure differential across a perforated plate attached in the center of the horizontal pipe was calibrated to measure airflow and to permit calculation of corresponding air velocities for the test chamber.

The perforated plate was calibrated for test chamber air velocities of 150 to 800 ft/min with a Miriam Model 50MC 2-4[3] laminar flow element attached to the inlet of the horizontal pipe. Calibration between 800 to 2500 ft/min was accomplished with a Pitot tube traverse in the vertical pipe 12 feet from the fan outlet. An air straightener in the vertical pipe provided uniform air distribution to Pitot tube and test chamber. The Pitot tube and laminar flow element were each removed after calibration.

Samples of the various materials were placed in the test chamber through the access door and spread out over the screen floor. The fan was started, operated at a low speed, and then gradually increased until the lightest portion of the subsample began floating above the screen floor. A minimum static pressure indication across the perforated plate was obtained with a micromanometer. Fan speed was then increased further until the entire subsample of material had been lifted from the screen floor giving a maximum pressure indication. The range of air velocities required to float the material in the entire subsample was then determined from the maximum and minimum pressure values. The moisture content (m.c.) of each subsample of material was determined by an oven method (1) after sample was removed from the test chamber.

Results and Discussion

PEANUT PODS AND RAISINS

Cumulative thickness distributions for peanut pods and raisins from the test lots are shown in Table 1. The distributions indicate that screening over a 22/64-in. slotted screen would have separated an average of about 47.6% (15.5 to 79.7%) of the raisins from Runner-type peanuts (all ranges shown are two standard deviations plus or minus the mean). Pod loss with this separation would have averaged about 0.3% and ranged from 0 to 0.6%. Similarly, screening over a 22/64-in. slotted screen would have removed an average of about 39.2% of the raisins from the Virginia-type peanuts with 0.1% loss of pods. Screening both the Runner- and Virginia-types of peanuts over an 18/64-in. slotted screen would have removed an average of about 21.1 and 20.9% of the raisins, respectively, with no loss of pods. These data show that part of the raisins can be removed from Runner- and Virginia-type peanuts with small losses of whole pods by screening with slotted screens; however, other materials such as LSK will also be separated with the raisins with screening. The percentages and sizes of raisins vary between lots of peanuts because of differences in maturity and harvest machinery operation. Therefore, the versatility of changing screen sizes is desirable for partial removal of raisins from pods by screening.

The distribution of raisins from Spanish-type peanuts was not determined because of an insufficient number of samples. Observed samples, however, contained fewer raisins than comparable samples of Runner- or Virginia-type peanuts. Separation of raisins from Spanish-type peanuts tends to be less of a problem because of the more determinant fruiting characteristics of the plant.

Ranges of flotation velocities for the different sizes of Spanish-, Runner-, and Virginia-type peanut pods are shown in Figs. 2, 3, and 4, respectively. The air velocity range for the three types was from 1000 to 2700 ft/min. Pods from Runner-type peanuts had the widest range of flotation velocities (1000 to 2500 ft/min). Flotation velocity increased with pod thickness for all types of peanuts. The increase averaged 3% for each 2/64 in. increase in pod thickness for Spanish, 4% for Runner, and 2% for Virginia. However, size separation by pod thickness could not have been accomplished with aspiration because the flotation velocity ranges between sizes overlapped a minimum of 24%. The average m.c. and standard deviation for each type of peanut are shown in Table 2. The smallest size pods ranged 1 to 3% higher in m.c. than the larger pods. This variation, however, had little effect on the measured flotation velocities.

Table 1. Cumulative thickness distributions of pods and raisins falling through screens.

Slot width of screen†	Material falling through screen: Runner-type Raisins Cumul-tive	Runner-type Raisins Standard deviation	Runner-type Pods Cumula-tive	Runner-type Pods Standard deviation	Virginia-type Raisins Cumula-tive	Virginia-type Raisins Standard deviation	Virginia-type Pods Cumula-tive	Virginia-type Pods Standard deviation	Spanish-type‡ Pods Cumula-tive	Spanish-type‡ Pods Standard deviation
(In.)	(%)		(%)		(%)		(%)		(%)	
38/64			97.53	1.17	99.51	0.27	72.46	15.22		
34/64			65.98	7.37	96.56	2.87	38.51	21.41	99.46	0.52
30/64	97.94	2.66	20.43	8.04	84.17	13.03	12.57	11.51	97.73	1.93
26/64	80.97	12.81	2.76	1.24	63.26	23.21	1.74	2.02	81.38	5.55
22/64	47.61	16.05	0.25	0.16	39.23	21.99	0.09	0.09	23.10	8.64
18/64	21.09	12.83			20.86	17.63			1.00	1.75
16/64	11.09	9.34			14.04	13.18				

† Screens had 3/4-in.-long slots.

‡ Raisins omitted because of lack of sample replication.

[3]Mention of a trademark or propriety product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

A comparison of the flotation velocities of the raisins from the Runner- and Virginia-type peanuts is shown in Fig. 5. Flotation velocity ranges between sizes within each type overlapped a minimum of 50%. Complete removal of all raisins from the pods by aspiration would have removed some of each size

Table 2. Average moisture contents of Spanish-, Runner-, and Virginia-type peanut pods.

Peanut type	Average moisture content (wet basis)	Standard deviation
	(%)	
Spanish	7.23	1.12
Runner	7.24	1.44
Virginia	7.59	2.11

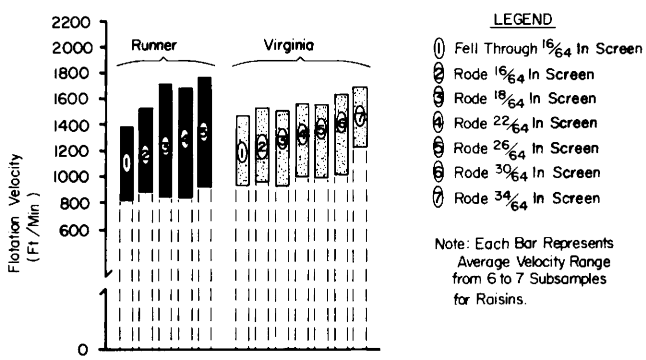

Fig. 5. Comparison of the flotation velocity ranges for the different sizes of Runner- and Virginia-type raisins.

of peanut pods. However, an air velocity of 1100 ft/min would have removed a portion of the raisins and essentially no pods.

Table 3 shows the average m.c. and standard deviation for the raisins from Runner- and Virginia-type peanuts. There was no correlation of flotation velocity and m.c.

Table 3. Average moisture contents of Runner-, and Virginia-type raisins.

Peanut type	Average moisture content (wet basis)	Standard deviation
	(%)	
Runner	12.78	4.65
Virginia	15.91	6.52

LOOSE SHELLED KERNELS

A comparison of the flotation velocities obtained for the whole, split, and oil stock kernels separated from the LSK samples from all three types of peanuts is shown in Fig. 6. The ranges of velocities were nearly equal for all peanut types. A regression analysis indicated that some of the differences in velocity ranges between whole, split, and oil stock kernels could be attributed to differences in m.c. A separation of some of the whole kernels could have been made from the split and oil stock kernels with aspiration. However, the total ranges of flotation velocities obtained for the LSK were essentially the same as for peanut pods. This indicates little separation potential between LSK and pods with aspiration (Figs. 2, 3, 4, and 6).

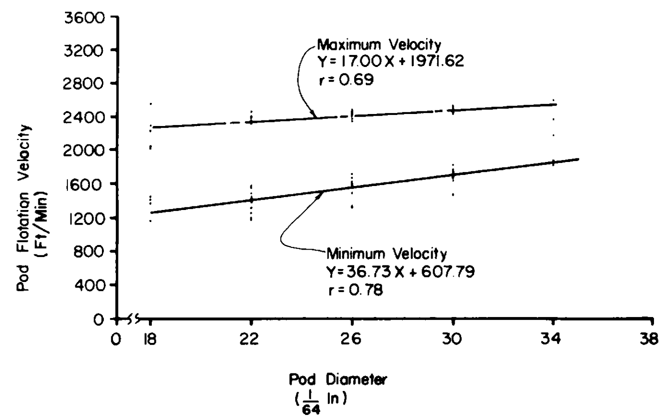

Fig. 2. The effect of pod thickness on flotation velocity of Spanish-type peanut pods.

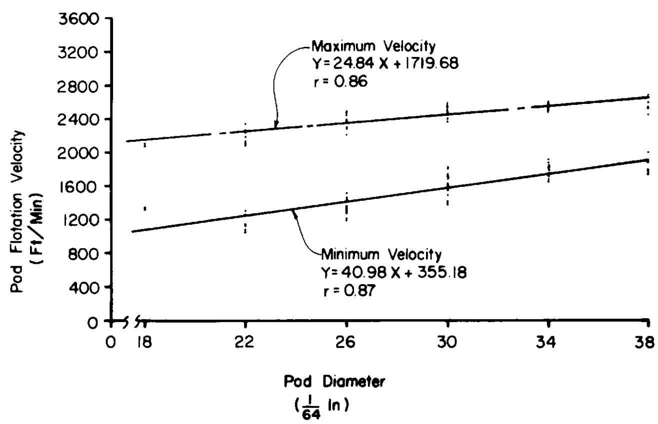

Fig. 3. The effect of pod thickness on flotation velocity of Runner-type peanut pods.

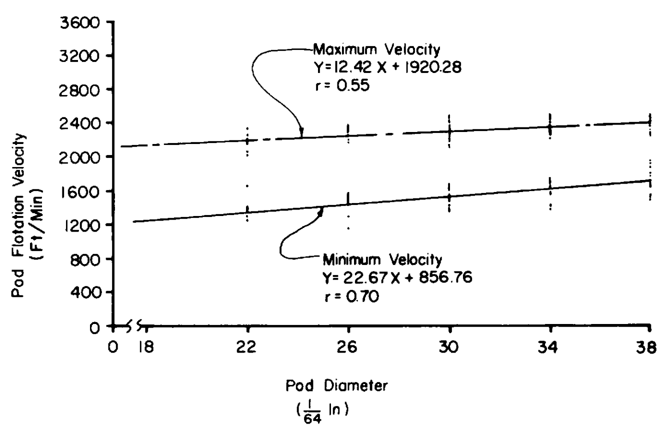

Fig. 4. The effect of pod thickness on flotation velocity of Virginia-type peanut pods.

VEGETATIVE FOREIGN MATERIALS

Cumulative length distributions of peanut vines, peanut taproots, weed stalks, and weed taproots are shown in Table 4. A maximum of 3.0% of these materials would have remained in the peanuts if an accurate length separation could have been made to remove materials greater than 1 in. in length. If these materials are not removed before shelling, they will be broken into smaller lengths which will make their removal more difficult in subsequent processes. Most of these materials were 1 to 5 in. in length with 92.9% of the peanut vines in this length category, 93.5% of the peanut taproots, 91.9% of the weed stalks, and 87.9% of the weed taproots.

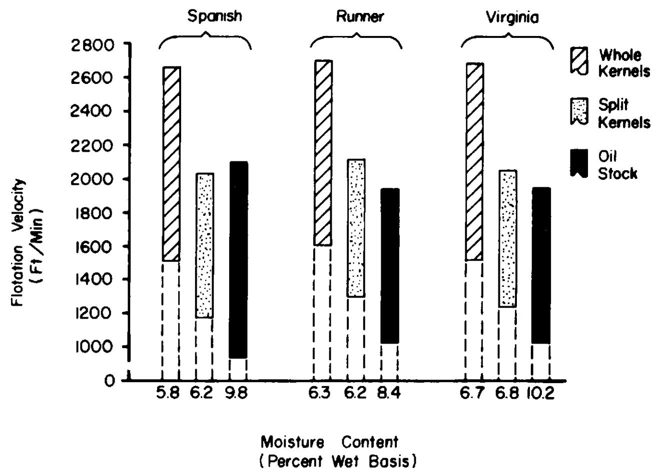

Fig. 6. Comparison of the flotation velocity ranges obtained for Spanish-, Runner-, and Virginia-type loose shelled kernels.

Table 4. Cumulative length distributions of peanut vines, peanut taproots, weed stalks, and weed taproots.

Length	Cumulative distribution			
	Peanut vines	Peanut taproots	Weed stalks	Weed taproots
(In.)	(%)	(%)	(%)	(%)
11-12	99.9			
10-11	99.5			
9-10	99.4			
8-9	99.2			
7-8	99.1	100.0	99.9	
6-7	99.0	98.8	98.2	100.0
5-6	97.6	97.5	96.1	90.9
4-5	94.8	94.2	93.6	90.9
3-4	87.9	77.5	85.5	78.8
2 1/2-3	72.4	48.8	69.4	54.6
2-2 1/2	53.9	26.1	53.3	39.4
1 1/2-2	29.2	9.4	29.6	30.3
1-1 1/2	11.6	0.7	14.8	18.2
1/2-1	1.9	0.7	1.7	3.0

A comparison of the flotation velocities of peanut taproots, vines, stems, and leaves is shown in Fig. 7. The stems and leaves had maximum flotation velocities of 1100 ft/min, slightly less than the minimum flotation velocities of the smallest peanut pods indicating potential for complete separation with aspiration (Figs. 2, 3, 4, 5, and 7). The velocity range of peanut vines was 30 to 50% above 1100 ft/min, indicating only partial separation potential without removing pods. The velocity ranges obtained for the three types of peanut vines were approximately equal.

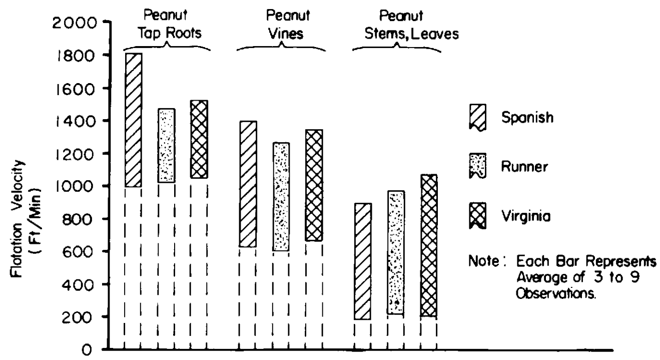

Fig. 7. Comparison of the flotation velocity ranges for Spanish-, Runner-, and Virginia-type peanut taproots, vines, stems, and leaves.

Figure 8 shows a comparison of the velocity ranges of six sub-samples of 2 to 3 in. and 3 to 6 in. peanut vines. Apparently, vine length had no effect on flotation velocity for the two sizes. Williams and Butler (5) found that lengths of 1, 2, and 3 in. also had no effect on flotation velocity. These data suggest there is no need to change aspiration velocity for varying vine lengths.

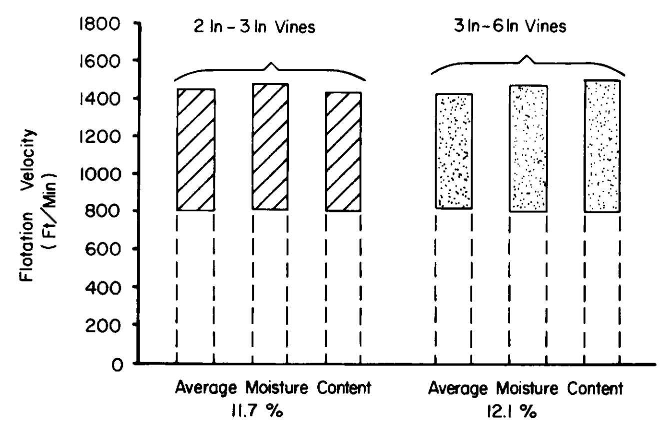

Fig. 8. Comparison of the flotation velocity ranges obtained for 2-3 in. length vines and 3-6 in. length vines.

Aspiration with air at a velocity of 1500 ft/min would have removed approximately 98% of the peanut vines along with a few sound pods (Figs. 2, 3, 4, 8, and Table 4). The average m.c. of the vines was 11.4%. Air velocities required to float peanut taproots fell within the velocity ranges required to float pods. However, aspiration at 1800 ft/min would have removed all of the taproots from pods, with some pods being separated with the taproots.

The flotation velocities and moisture contents of several other nonpeanut vegetative foreign materals are shown in Table 5. The flotation velocities for these materials ranged from about 550 to 2800 ft/min. Moisture contents of the foreign materials ranged from 9 to 18%.

All of the vegetative foreign materials and raisins,

Table 5. Flotation velocity ranges and moisture contents of non-peanut vegetative foreign materials.

Material	Flotation velocity minimum	Flotation velocity maximum	Moisture content
	(ft/min)	(ft/min)	(%)
Corncobs	1178	1929	9.3
Weed stalks			
Not woody	976	1585	10.1
Woody	906	1642	11.3
Wild cucumbers			
Whole	1384	2160	15.0
Pieces	557	1485	13.6
Nutsedge tubers	1604	2268	11.4
Maypop (passion flower fruit)	1292	1952	18.3
Horsenettle berries	1396	2823	16.3

except for part of the samples of whole cucumbers, nutsedge tubers, and horsenettle berries, had flotation velocities of less than 2000 ft/min. Aspirating peanuts containing foreign materials with air at 2000 ft/min will separate pods with low percentages of foreign materials from pods with large percentages of foreign materials. The use of this aspiration technique prior to precleaning will substantially reduce the volume of material that needs thorough precleaning and will allow conventional, high capacity, low efficiency machinery to be operated at lower flow rates and more efficiently. Lower capacity precleaning equipment can also be designed for higher efficiencies to separate smaller amounts of pods with greater concentrations of foreign materials.

SOIL AND ROCKS

Five of the lots of peanuts were grown on a Greenville soil, and contained 5.5, 8.5, 14.9, 39.0, and 46.5% of loose soil by weight. Essentially all of the soil was removed from the pods by screening with a small diameter, slotted screen. Loose soil can be easily removed from pods by screening because of the large difference in particle sizes. Soil, however, may cling to peanut hulls and require a more vigorous shaking or tumbling action for separation. The amount of soil is dependent upon the type of soil, m.c., and the pubescence characteristics of the variety. Peanuts with an excessive amount of soil should be cleaned prior to being dried to remove the potential restriction to airflow.

A cumulative thickness distribution of the rocks found in samples of peanuts grown on Tifton soil series is shown in Table 6. An average of 31.5% of the rocks could have been removed from the pods by screening over an 18/64-in. slotted screen. Separation of rocks and pods by conventional equipment is based on the principle of specific gravity rather than flotation velocity. The test equipment for determining flotation velocity could not supply a sufficient amount of air, and flotation velocities for the rocks and clods were not determined.

SPECIFIC GRAVITIES

The average range and standard deviation of specific gravities for 10 materials are shown in Table 7. Specific gravity ranges for most of the materials over-

Table 6. Cumulative thickness distribution of rocks in the peanuts grown on Tifton soil series falling through screens.

Screen diameter	Rocks falling through screen	
	Cumulative	Standard deviation
(In.)	(%)	
38/64	92.9	13.2
34/64	89.8	16.6
30/64	80.2	16.7
26/64	68.7	18.3
22/64	52.5	18.2
18/64	31.5	15.1
16/64	18.3	10.3

lapped the specific gravity range of pods as did flotation velocities. However, rocks and soil clods had specific gravities 2 to 4 times as great as pods. Some of the other materials, such as kernels, 2 to 3 in. taproots, and horsenettle berries had specific gravities that averaged 0.2 points greater than that of pods, indicating a partial separation potential.

Table 7. Specific gravities of peanut pods, kernels, and foreign materials.

Material	Specific gravity		
	Range	Average	Standard deviation
Peanut pods (Florunner)	0.333-0.664	0.567	0.091
Peanut kernels (Florunner)	.617-1.038	.953	.138
Peanut taproots			
2-3 in. long	.554-0.883	.700	.098
3-6 in. long	.531- .636	.518	.039
Peanut vines	.413- .652	.575	.075
Beggarweed stalks	.365- .525	.435	.056
Corncobs	.274- .584	.404	.090
Horsenettle berries	.572- .828	.729	.086
Raisins			
16/64-22/64 in. thick	.363- .543	.478	.053
less than 16/64 in. thick	.518- .688	.592	.044
Rocks (Tifton soil series)	1.191-2.722	2.298	.506
Soil clods	1.630-1.870	1.769	.082

Conclusions

Differences in the relative thicknesses of pods, raisins, and rocks indicated a basis for partial separation. More than 99% of all the pods had thicknesses greater than 18/64 of an inch. An average of 22% of the raisins and 32% of the rocks were less than 18/64 in. in thickness. Frequency distributions for peanut vines, weed stalks, and taproots revealed that more than 96% of these materials were longer than 1 in.

Rocks and soil clods had specific gravities 2 to 4 times as great as pods. A substantial amount of these materials could be removed from pods with a specific gravity separation.

Flotation velocities for all of the materials varied from approximately 100 to 3000 ft/min. Most materials had velocity ranges that fell between 1000 to 2700 ft/min which coincided with the velocity ranges of peanut pods. Aspirating with air at 2000 ft/min would remove most foreign materials with the lighter pods and reduce the flow rate of material that must be further precleaned. The remaining heavy pods should then be passed over a specific gravity separator for removal of the heavier foreign materials such as rocks and soil clods.

Both the maximum and minimum flotation velocities increased with pod thicknesses in all types of peanuts. Complete separation, however, between the largest and smallest size pods can not be accomplished with aspiration, because the flotation velocity ranges overlapped.

Flotation velocities for the raisins also increased with thickness. Partial separation of the raisins from pods can be accomplished by aspiration with the removal of some of the lighter pods.

Most of the other materials with exception of peanut stems, leaves, vines, weed stalks, and wild cucumber segments, had flotation velocities similar to pods. Length had no effect on the flotation velocities of peanut vines.

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