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Research Note

Some Engineering Properties of Pumpkin (*Cucurbita moschata*) Seeds

ABSTRACT

Manual dehulling of pumpkin seeds is very tedious. In order to explore the possibility of developing a mechanical dehulling process, the engineering properties of the seed kernels and hulls, such as dehulling load, surface roughness, transport velocity and densities, were studied. Effects of size and moisture conditioning on some of the properties were also evaluated. The results showed that it is possible to dehull the seeds mechanically by a system in which the sharp tips of the seeds impinge on a hard surface. It is also possible to separate kernels, hulls and any unhulled seeds in suitable equipment using the differences in their properties such as surface roughness, densities and transport velocities.

INTRODUCTION

Pumpkin (*Cucurbita moschata*) seed kernels are reported to be rich in protein and fat and are considered highly nutritious (Teotia, 1988). In Italy pumpkin seeds are used for human and animal food after being peeled, roasted and salted (Cirilli, 1971). In Nigeria pumpkin seeds are boiled or roasted and made into paste or soup prior to consumption. The seed oil is used in native Nigerian cookery (Esiaba, 1982). Pumpkin seeds are thus a potential source of edible oil. The oil being highly unsaturated, it may also be used as a drying oil for paints and varnishes (Asiegbu, 1987). However, commercial exploitation of this seed as a source of oil and protein would be hampered because of the hull which is difficult to remove.

Pumpkin kernels are normally obtained by manual dehulling of the seeds, which is similar to that of melon seeds (Ramakrishna, 1986) and is very tedious.

The mechanical dehulling of pumpkin seeds, however, has not been attempted so far. Ramakrishna (1986) examined melon seeds for their physical characteristics based on which a mechanical dehulling process

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was developed (Anon., 1983). Teotia and Ramakrishna (1989) further measured the different densities of seeds and their constituents to explore better separation techniques, especially for kernels from seeds.

To explore the possibility of developing a similar or alternative mechanical dehulling process, the engineering properties of pumpkin seeds, kernels and hulls were studied.

EXPERIMENTAL

Determination of composition

The seeds of a commercial pumpkin (*Cucurbita moschata*) variety were procured from a local seed shop. The seeds were manually dehulled to obtain whole kernels and hulls. Seeds were analysed for their proximate composition using AOAC (1975) methods. Average values of two measurements are reported on a moisture-free basis.

Size distribution

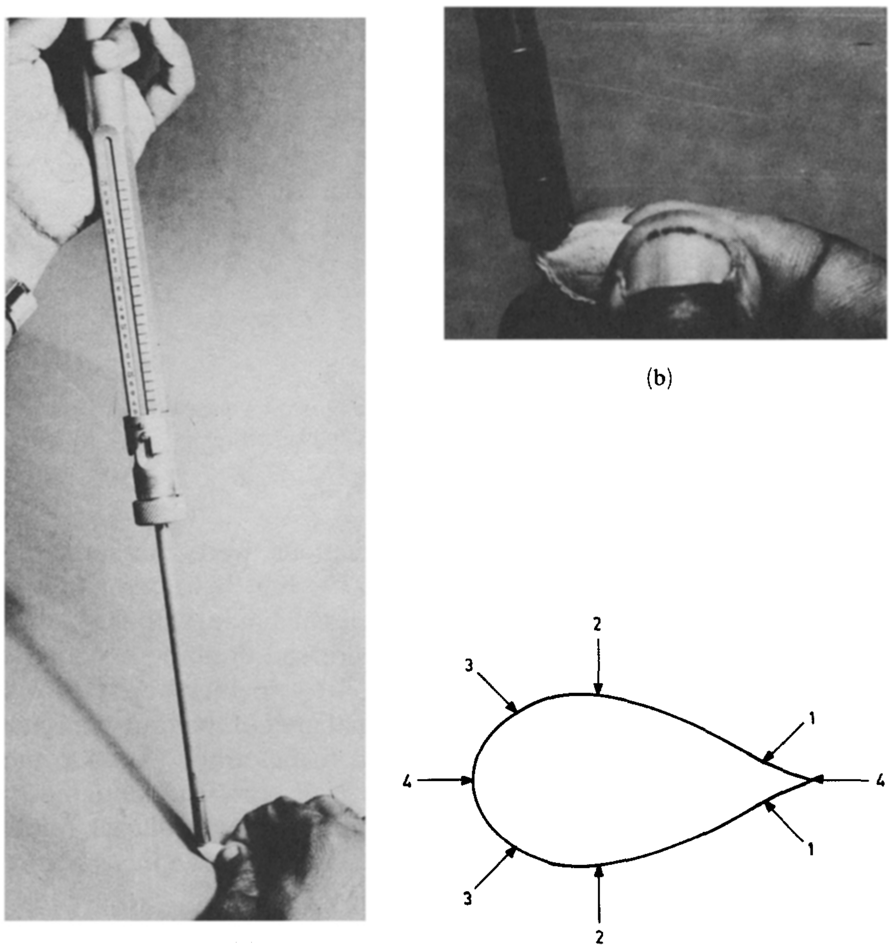
The lengths of a random sample of 100 seeds were measured using vernier callipers. The seed, its kernel and hull were weighed on an analytical balance to ascertain their proportions. The seeds were graded into large, medium and small based on their lengths to enable the effect of size on some of the properties to be studied.

Moisture conditioning

A series of 20 g samples of seeds were soaked in tap water for different periods of 10, 20, 30, 40, 50 and 60 min. The seeds were lightly dabbed with blotting paper to remove adhering water. The moisture absorbed by the seeds and their fractions was determined using an analytical balance. Seeds soaked for 15 min (wet seeds) were used to study the effect of conditioning on some of the properties.

Measurement of dehulling load

A fruit pressure tester (D. Ballauf Mfg Co., Inc., Washington, DC — Fig. 1(a) and (b)) was used to assess the hull breaking load. The seed was held firmly with pliers or fingers and the periphery of the seed at different points (Fig. 1(c)) was pressed against the tip of the fruit pressure tester. It was observed that the hull could be opened only at position 1, that is, at the edge near the pointed tip, by applying a suitable load. At all other



(a) (c)

Fig. 1. (a) General view of fruit pressure tester; (b) close-up of pressure tester with pumpkin seed under test; (c) positions at which the load was applied.

points, the seed was crushed or broken. The load required to open the hull at the edge near the tip was reported as the hull breaking load (average value of 10 measurements).

Measurement of surface roughness

The surface roughness of the seed and kernel fractions was measured with a Surtronic surface roughness meter (type 112/100 — Fig. 2), as the arithmetic mean of variations from the centre line of the surface profile. Average values of 10 measurements are reported.

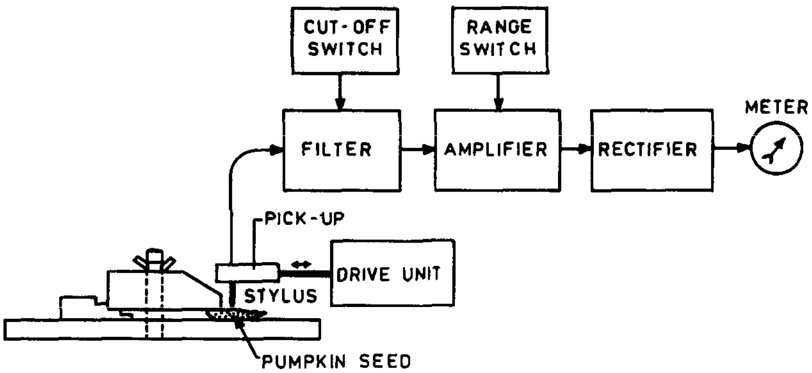


Fig. 2. Schematic block diagram of Surtronic equipment for measurement of surface roughness of pumpkin seeds and kernels.

Measurements of transport velocities

The transport velocities of different fractions were measured in a laboratory air separator (VEB Petkus K293 — Fig. 3). Material flow was adjusted initially to a minimum (2–3 particles at a time) with the help of a magnetic vibrator. Air flow was slowly increased until the material was carried away to the separator. The transport velocities were calculated knowing the air flow rate and cross-sectional area of the transport chute. The feed rate was then slowly increased to determine the maximum permissible feed rate beyond which the transport was hindered and material fell back down into the bin. One hundred grams of each fraction was used for each measurement and the average of two measurements was reported.

Measurement of densities

True density, bulk density and apparent densities of the seeds, kernels and hull were determined. The average value of two measurements was reported. The porosity and limiting moisture gain were calculated from the measured average densities.

The definitions of the different densities, methods of determination and calculation of porosity and limiting moisture gain from densities were described in detail by Teotia and Ramakrishna (1989).

RESULTS AND DISCUSSION

The composition of the pumpkin seeds used in the study is given in Table 1. Kernels contain mainly fat and protein while the hull contains fibre. The size distribution of the seed sample is given in Table 2. There is an

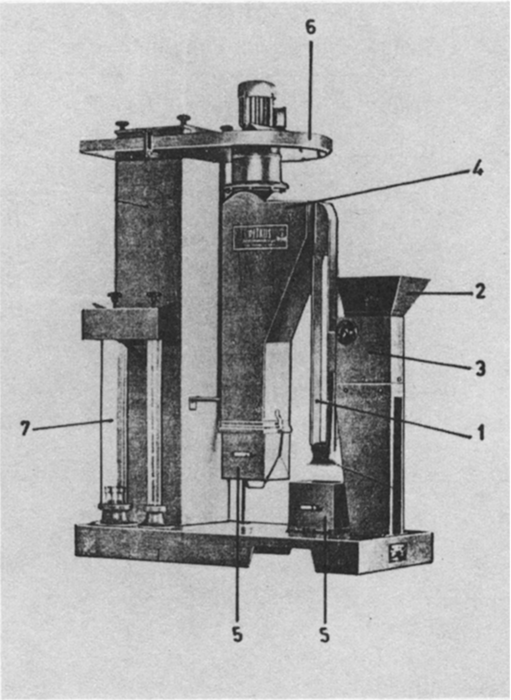


Fig. 3. Petkus laboratory air separator: 1, transport chute; 2, feed hopper; 3, vibrator; 4, separator; 5, bins; 6, fan; 7, air measuring tubes.

TABLE 1
Percentage Composition of Pumpkin Seeds (Moisture-free Basis)

Component	*Seeds*	*Kernels*	*Hulls*
Mineral matter	4·80	4·96	2·72
Ether extract	45·83	46·20	0·98
Crude fibre (includes cellulose)	12·67	1·16	38·04
Protein ($N \times 6{\cdot}25$)	32·52	37·55	4·35
Carbohydrate (by difference)	4·18	10·13	53·91

increase in the length:breadth ratio, seed weight and thickness and a decrease in kernel:hull weight ratio with increase in size. The moisture contents of the different fractions of both dry and wet seeds are given in Table 3. The moisture content of the seed increased from 5·6 to 27·2% during 15 min soaking.

The water absorbed by different components of the seed during soaking is shown in Fig. 4. The moisture absorption rate was found to be

TABLE 2
Size Distribution of Pumpkin Seeds

Size	*Length (cm)*	*% Sample*		*Average seed wt (mg)*	*Length: width ratio*	*Average thickness (cm)*	*Kernel: hull ratio (wt/wt)*
		No. (%)	*Wt (%)*				
Large	>1·7	22	25·95	189·9	2·11	0·34	2·88
Medium	1·1–1·7	65	64·45	159·7	1·65	0·27	3·59
Small	<1·1	13	9·60	118·9	1·71	0·20	3·76

TABLE 3
Moisture Contents of Dry Seeds and of Seeds Soaked for 15 Min (see text) and their Fractions

Component	*% Moisture in*		*% Gain in moisture during soaking*
	Dry seed	*Wet seed*	
Seed	5·6	27·2	30·0
Kernel	4·77	11·5	8·0
Hull	10·86	58·1	113·0

greatest during the first 10–15 min of soaking. About 75–80% of the moisture absorbed was in the hull, with only 20–25% in the kernel. It was also observed that the kernel became soft during soaking.

Hull breaking load

The hull breaking loads for dry and wet seeds are given in Table 4. The hull breaking load for dry seeds was found to vary from 3 to 5 kg whereas for wet seeds it varied from 1·4 to 3·6 kg. The hull breaking load for wet seeds is 25–35% less than for the dry seeds. The size of the seed did not affect the hull breaking load (Table 4).

The results indicate the possibility of mechanical dehulling of seeds in order to obtain the whole kernels by a system in which the sharp tip of the seed impinges on a hard surface.

Surface roughness

The surface roughness of the seed and kernel was measured for both dry and wet seeds of all three sizes. From the results it can be concluded that size of seed and moisture conditioning are unrelated to the surface

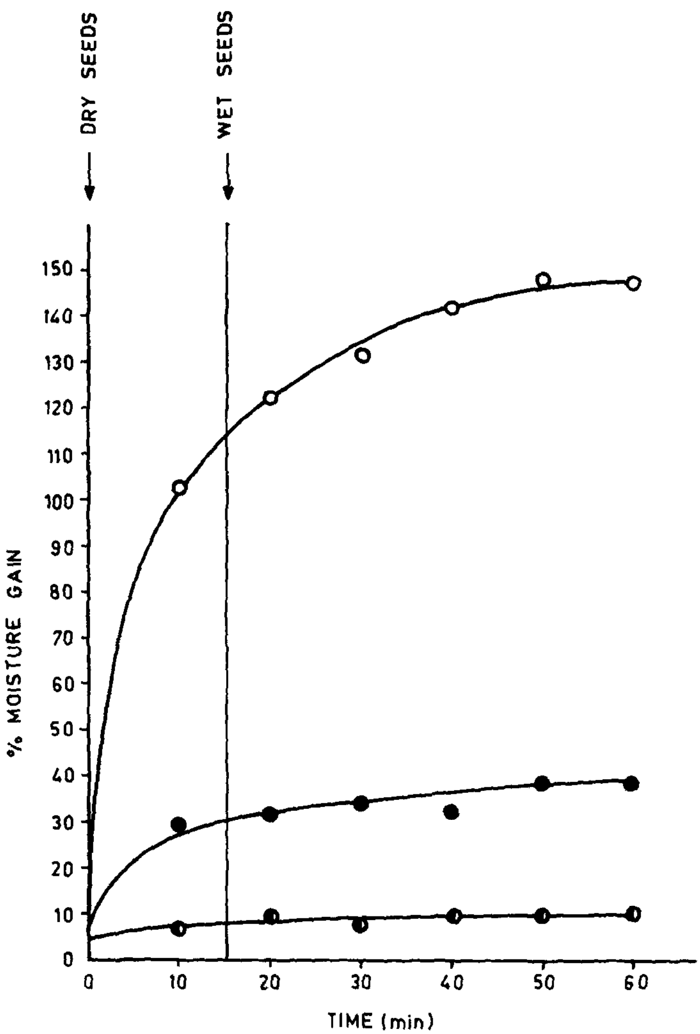


Fig. 4. Water gain by pumpkin seeds, kernels and hulls during soaking: ●, seeds; ◐, kernels; ○, hulls.

roughness. However, there is a distinct difference in roughness between seeds and kernels (Table 5), kernels being rougher than seeds. This difference in roughness may be useful in separating seeds from kernels in vibratory separators.

Transport velocity

The transport velocity for the hulls (5 m/s) is much less than for the seed or the kernel (10 m/s) (Table 6). Aspiration techniques, therefore, could

TABLE 4
Hull Breaking Load

Size		*Hull breaking load (kg)*	
		Dry seed	*Wet seed*
Large	Average	3·5	2·6
	Minimum	3·1	1·4
	Maximum	4·9	3·6
Medium	Average	4·0	2·5
	Minimum	3·0	1·5
	Maximum	5·0	3·5
Small	Average	3·7	3·5
	Minimum	3·1	1·6
	Maximum	5·0	3·4

TABLE 5
Surface Roughness

Size		*Roughness (μm)*			
		Dry seeds	*Dry kernels*	*Wet seeds*	*Wet kernels*
Large	Average	3·20	4·50	3·37	3·98
	Minimum	2·66	3·80	2·62	3·05
	Maximum	3·74	5·21	4·13	4·86
Medium	Average	2·84	4·60	3·35	5·65
	Minimum	2·15	3·76	2·56	4·05
	Maximum	3·59	5·58	4·15	6·24
Small	Average	3·70	4·50	3·15	5·50
	Minimum	2·87	3·73	2·39	4·49
	Maximum	4·52	5·24	3·94	6·08

be used to separate the hull from seed and kernel fractions. The moisture conditioning slightly increased the transport velocity required for the seeds and consequently reduced the permissible feed rate.

Densities

The true density of the seeds is greater than that of the kernels, whereas the bulk density is less (Table 7). However, the differences in both true

TABLE 6
Transport Velocities

Component	Dry		Wet	
	Maximum feed rate (g/s)	*Air velocity (m/s)*	*Maximum feed rate (g/s)*	*Air velocity (m/s)*
Seed	8·98	10·12	8·19	10·95
Kernel	8·84	9·03	7·23	9·89
Hull	2·77	4·98	2·20	5·12

TABLE 7
Densities

Component	Density (kg/m³)			Porosity	Limiting moisture gain (%)
	True	*Bulk*	*Apparent*		
Seed	1 220	350	750	—	33·33
Kernel	1 170	400	1 070	0·085 5	—
Hull	1 650	100	420	0·745 5	138·10

density and bulk density are not significant. It is therefore difficult to separate them using either density separators or air classifiers.

The apparent density of the seeds is less than the density of water whereas the apparent density of the kernels is greater than that of water. This property can be used to design a suitable batch or continuous separation system for separating seeds from kernels. But the hulls of the seeds are more porous than the kernels. Therefore, seeds absorb water and their apparent density increases during their separation from kernels using a water flotation system. Once the apparent density of the seeds is equal to or greater than the density of water, such a method of separation is not feasible. This limits the permissible moisture gain for the seeds to 33%.

CONCLUSIONS

The properties of the pumpkin seeds, hulls and kernels are such that a mechanical dehulling process to obtain whole kernels from pumpkin seeds should be possible. The seed, kernel and hull fractions obtained by mechanical dehulling should be separable by air classification and flotation, based on the differences in the relevant properties.

Moisture conditioning reduced the force required to break the hull. It increased the transport velocities of the components slightly and consequently reduced the permissible transport feed rate. Since kernels became soft during moisture conditioning, moisture conditioning to a suitable degree may be expected to reduce the risk of kernel breakage during mechanical dehulling.

REFERENCES

Anon. (1983). *CFTRI Newsletter*, **5** (4), 1.

AOAC (1975). *Official Methods of Analysis*, 12th ed. Association of Official Analytical Chemists, Washington, DC.

Asiegbu, J. E. (1987). Some biochemical evaluation of fluted pumpkin seeds. *J. Sci. Food Agric.*, **40** (2), 151–5.

Cirilli, G. (1971). Chemical characteristics of mechanically recovered pumpkin seeds. *Industrie. Alimentari*, **102** (12), 82–4.

Esiaba, R. D. (1982). Cultivating the fluted pumpkin in Nigeria. *World Crops*, **34** (2), 70–2.

Ramakrishna, P. (1986). Melon seeds — evaluation of physical characteristics. *J. Fd Sci. Technol.*, **23** (3), 158–60.

Teotia, M. S. (1989). Advances in chemistry and technology of pumpkins. *Indian Fd Packer*, (in press).

Teotia, M. S. & Ramakrishna, P. (1989). Densities of melon seeds, kernels and hulls, *J. Food Eng.*, **9** (in press).

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