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Cleavage damage due to rapid drying in pea-shaped seeds of chickpea (*Cicer arietinum*)

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The world collection of chickpea (*Cicer arietinum* L) germplasm assembled at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) centre consists of 15 939 accessions (as on October 1989), originating from 42 countries. The entire germplasm is conserved as seed in the genebank under medium-term (+4°C and 20% relative humidity) and long-term (−20°C) conditions For long-term preservation the recommended moisture content of the seed is 5 ± 2% (IBPGR, Rome 1976), but in tropical and sub-tropical environments, where the ambient relative humidity is high, it is difficult to dry the seeds to such low moisture levels using the conventional sun-drying and heated air-drying methods without affecting long-term viability.

Cromarty *et al* (1982) suggested that seed lots of all species can be safely dried to low moisture contents at 15°C and 15% relative humidity (RH) by using sorption-type drier with secondary refrigeration. A drying-cabinet built to this design has recently been procured for use at ICRISAT genebank and the seeds of several crop species are being dried to the desired moisture levels without perceptible damage for subsequent long-term storage.

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In chickpea, however, there are a few accessions with round (pea-shaped) seeds which, when subjected to drying at 15°C and 15% relative humidity, suffered cleavage damage because of splitting of their seeds along the cotyledons. Cleavage damage during drying is known to occur in soybean [*Glycine max* (L.) Merr.] (Cromarty *et al* 1982), but in chickpea it was observed for the first time and is reported in this paper.

Four pea-shaped chickpea accessions, viz 'ICC 6026', 'ICC 6305', 'ICC 8541' and 'ICC 8351', were used in this study. Among these, the first 3 have perfectly round seeds, whereas the fourth has seeds semi spherical in shape. 'ICC 4948' ('G 130'), a *desi* variety with angular seeds, and 'ICC 4973' ('L 550'), a *kabuli* variety with owl's head shaped seeds, served as the controls The moisture content of seed and the percentage of normal germination were determined for each seed lot following the methods suggested by the International Seed Testing Association (ISTA, Zurich 1985) Visible damage to the seeds was assessed by physical examination of 100 seeds in 2 replicates of 50 each with a magnifying glass

The seeds were dried in 2 environments: (*i*) in a drying-cabinet at 15 ± 1°C and 15 ± 2% relative humidity as aspirated thin layers on perforated sieves (DC), and (*ii*) in a desiccator at 15°C by holding the seeds in small mesh cribs over silica gel (gel : seed ratio 1 : 2, on weight basis) regenerated on alternate days (SG). The seeds were dried for 10 days in the drying cabinet or for 2-3 weeks over the silica gel, which reduced the moisture content of each sample to 7-8% (wet weight basis). After drying, the extent of damage suffered by the seeds in each drying environment was determined by physical examination of individual seeds and by conducting germination tests. The seeds were humidified for 24 hr over water in a desiccator before germination to avoid imbibition injury.

When dried at 15 ± 1°C and 15 ± 2% relative humidity, the seeds of the pea-shaped varieties split between the cotyledons, creating a gap (Fig 1). The accessions with perfectly round seeds had almost all seeds damaged, whereas in 'ICC 8351' (semi-spherical seeds) and in 'ICC 4973' (owl's head-shaped seeds) only 28 and 12% of the seeds were damaged respectively (Table 1). In the latter, the damage was mostly seen as cracks in the seed-coat. The angular seeds ('ICC 4948'), however, were not affected by drying (no visible damage was observed). The pea-shaped seeds that suffered extensive damage during drying also showed reduced germination (Table 1). The seeds of all varieties dried over silica gel, on the contrary, suffered very little damage, although it took considerably longer time to achieve the same level of moisture content as that with drying-cabinet. The percentage of germination of the seeds following drying was also not significantly different from the initial value in all the accessions (Table 1).

The cleavage damage in the pea-shaped chickpea resulted from rapid drying, which occurred when the seeds were exposed to the dry air at 15% relative humidity in the drying-cabinet. The initial moisture content of the seed lots used in this experiment was high (about 13% or more). Consequently the gradient in vapour pressure level between the seed and the air of the drying environment that affects the rate of drying was also large. Under such conditions the initial moisture loss from the testa will be significantly greater than that from the cotyledons. Hence the testa shrinks more rapidly. and the resulting stress leads to splitting of the seed-coats between the cotyledons (Cromarty 1984). The reasons for the absence of cleavage damage in the angular and owl's head-shaped seeds under similar conditons of

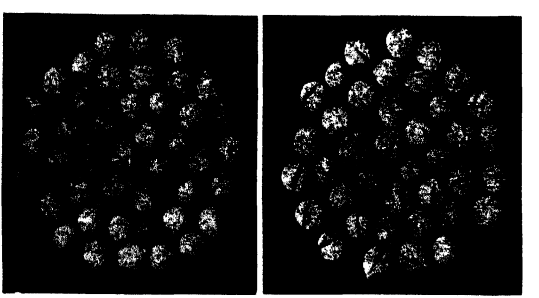

Fig 1 Cleavage damage in 'ICC 8541'. *Left*, Normal; *right*, damaged seeds

Table 1 Influence of seed-drying conditions on moisture content (%), damage to seeds and germination (%) in different chickpea varieties

Variety	Seed shape	Moisture content (%)			Damaged seeds (%)			Germination (%) ± SE		
		BD	DC	SG	BD	DC	SG	BD	DC	SG
'ICC 4948'	Angular	13.4	7.5	7.9	0	2	0	99.5 ± 0.50	99.0 ± 1.00	98.0 ± 0.82
'ICC 4973'	Owl's head	14.6	6.5	7.7	0	12	1	98.0 ± 0.81	95.5 ± 2.22	96.0 ± 0.00
'ICC 8351'	Semi-spherical	14.4	6.9	7.7	4	28	4	77.0 ± 2.38	75.5 ± 2.63	78.5 ± 4.86
'ICC 6026'	Round (pea)	14.0	7.1	7.6	1	100	7	81.5 ± 2.22	72.0 ± 3.26	79.5 ± 1.50
'ICC 6305'	Round	14.7	7.3	7.8	4	100	8	71.5 ± 4.71	60.5 ± 1.89	74.5 ± 3.09
'ICC 8541'	Round	13.9	7.5	7.7	2	100	2	70.0 ± 5.29	56.0 ± 0.82	69.5 ± 2.63

BD, Before drying; DC, after drying in drying-cabinet at 15°C and 15% relative humidity; SG, after drying over silica gel at 15°C drying are not clearly known. One possible explanation is that the seed-coats of the angular and owl's head-shaped seeds adhere more tightly to the cotyledons than those of the pea-shaped seeds.

Caution is therefore necessary while drying the pea-shaped chickpea seeds. Damaged seeds do not survive as long as the non-damaged seeds, since the broken seed-coats provide easy access to microflora—which promote seed deterioration (Justice and Bass 1978). Although cleavage damage could be avoided by slow drying, using silica gel, it is impracticable on large scale. Alternative drying procedures for safe drying the pea-shaped seeds to low moisture contents are under study. Preliminary results suggest that cleavage damage could be minimized by following a 2-stage drying procedure in the drying-cabinet; with an initial slow drying at 15°C and 30-40% relative humidity until the seed-moisture content is reduced to about 9% or less, followed by a second-stage drying at 15°C and 15% relative humidity to bring down the moisture content to about 7% as required for long-term preservation.

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