

Decorticating Pearl Millet and Grain Sorghum in a Laboratory Abrasive Mill¹

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ABSTRACT

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The decortication behavior of random mating populations of pearl millet and cultivars of grain sorghum was studied with Shepherd's modification of the Udy cyclone mill. Sorghum bran was removed in large flakes during decortication, and pearl millet bran was removed in smaller flakes. Neither sorghum nor millet was degermed during decortication. Millets grown in

Sudan required less time to decorticate than Kansas-grown millets. Fractionation of the decorticate and the decorticated grain, using screens and a seed blower, indicated that differences in decortication rate were largely related to endosperm softness.

Milling characteristics are important in determining grain quality. Decorticating behavior of millet and sorghum influences their palatability and cooking quality (Desikachar 1977, Kapasi-Kakama 1977).

Equipment used to study decortication of sorghum and millet include barley pearlers or similar machines (Anderson et al 1969, Hahn 1969, Rooney et al 1972, Stringfellow and Peplinski 1966), rice hullers and polishers (Anderson and Burbridge 1971, Raghavendra and Desikachar 1964, Virakthamath et al 1971), wire brush types of mills (Rooney and Sullins 1969, Weinecke and Montgomery 1965), and peelers (Shoup et al 1970). Few laboratory decorticating mills for small grains have been described. Barber (1972) modified a laboratory decorticating mill originally described by Hogan et al (1964). It consisted of a tangential abrasive device effective in decorticating but deficient in collecting the decorticate (material removed from the grain).

Reichert and Youngs (1976) concluded that abrasive techniques were the best for sorghum and pearl millet. Shepherd (1979) recently developed a laboratory decorticating mill for small seeds; it is an abrasive type of mill, an efficient decorticator, that provides convenient methods of collecting the fines removed and the decorticated grain.

Our objective was to determine decortication responses of random mating populations of pearl millet (*Pennisetum americanum* (L.) Leeke) and cultivars of grain sorghum (*Sorghum bicolor* (L.) Moench) using Shepherd's modification of the Udy cyclone mill. We wanted to see if decortication behavior could be used to differentiate between millet populations grown in the United States or Sudan, among sorghum cultivars, and between millet and sorghum samples.

MATERIALS AND METHODS

Materials

Proximate compositions of the pearl millet samples are shown in Table I. Pedigrees of the millet cultivars grown in Kansas were: HMP1700 (PI263540/Tift 23 DB₁/2/Tift 239 DB₂/2*Serere 3A); HMP550 (Tift 23 DB₁/2*PI185642); RMPI(S)CI (Parentage from Serere 3A, Serere 17, and Tift 239 DB₂), and Serere 3A, developed by Serere Experimental Station, Uganda, Africa. Pedigrees of the Sudanese yellow and green millets selected from the marketplace in Khartoum, Sudan, were unknown, but they represented "good" (green) and "poor" (yellow) quality grains, judged on the basis of

flavor characteristics assigned to them by villagers and on market prices (Badi⁴).

Sorghum cultivars SRAI W6 and SRAI W4 were developed at

⁴S. M. Badi, Food Research Center, Khartoum, Sudan, Africa. Personal communication, 1979.

TABLE I
Proximate Composition of Pearl Millets and Grain Sorghums

Sample	Protein (%)	Ash (%)	Fat (%)
Pearl millets			
HMP1700 ^a	14.7	1.6	6.9
HMP550 ^a	13.6	1.8	7.1
RMPI(S)CI ^b	11.1	1.4	6.8
Serere 3A ^c	13.5	1.6	6.2
Sudan Yellow ^d	14.5	2.0	7.8
Sudan Green ^d	12.0	1.5	5.9
Grain sorghum			
SRAI W4 ^e	9.3	1.5	3.5
SRAI W6 ^e	9.8	1.2	2.8
Dwarf White ^e	13.5	1.8	3.2

^aGrown in Hays, KS, 1977.

^bGrown in Manhattan, KS, 1976.

^cGrown in Hays, KS, 1975.

^dGrown in Sudan.

^eGrown in Scott City, KS.

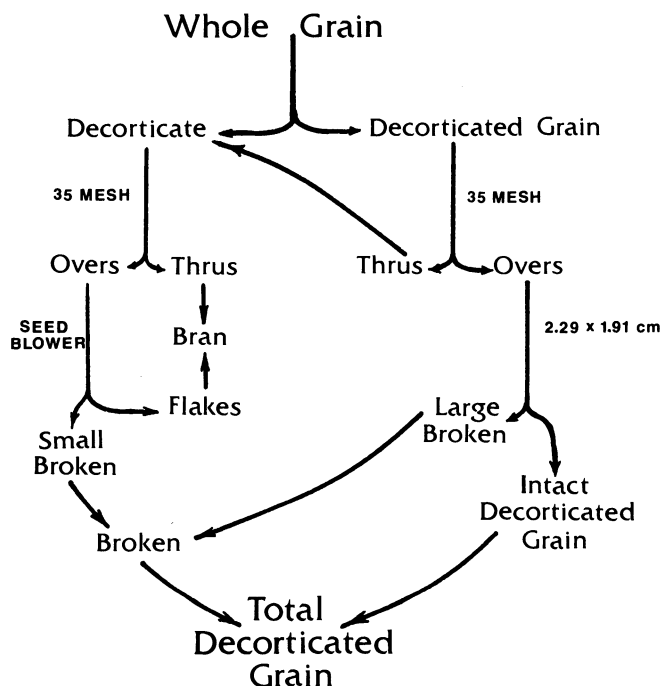


Fig. 1. Fractionation scheme for decorticated sorghum.

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the Seed Research Associates, Scott City, KS. The Dwarf White (PI400226) sample originated in Sudan but was grown in Kansas. Proximate analyses of all the samples are shown in Table I.

Grain Cleaning

Light debris was removed from pearl millet samples with an aspirator, and the grains were passed over a 2.29×1.91 -cm slotted sieve to remove small seeds. The sorghum samples were cleaned and sized over a screen having 0.32-cm, round perforations. After cleaning the grains, we handcleaned the overs to remove broken kernels and seeds with adhering glumes. The latter were deglumed in the decorticating mill with a rubber liner replacing the abrading surface. Deglumed seeds were combined with the hand-cleaned overs for decortication.

Decortication

Decortication was performed with a modified Udy cyclone mill (Shepherd 1979). The grain was fed into a chamber in which air from an impeller conveyed the kernels against a cylindrical abrasive surface. Particles small enough left the grinding compartment through a screen and were carried by an air stream to a cyclone connected to a glass receiver. To empty the grinding chamber, we removed the screen and reversed the motion of the impeller. The

debranned sample was collected into a clean glass receiver.

For pearl millet decortication, the Udy cyclone mill was fitted with a four-blade impeller measuring 10.8 cm in diameter from blade tip to blade tip, a 60-mesh grit abrasive surface, and a screen perforated with round holes 1 mm in diameter. The mill was operated at 1,800 rpm for both Kansas and Sudanese millets. The latter were also decorticated with an 80-mesh grit at 1,500 rpm.

For sorghum decortication studies, we fitted the mill with a four-blade impeller, a 60-mesh grit abrasive surface, and a perforated screen with 0.23-cm round holes. The mill was operated at 1,800 rpm.

To determine times required to obtain 5, 10, 15, and 20% decortication, we used a single 10-g sample of each millet in preliminary trials. The fraction removed was collected and weighed for several successive periods. Optimum decortication times were selected based on the information obtained.

Scanning Electron Microscopy

Representative samples of intact and decorticated sorghum and millet kernels were fractured with a dull razor, mounted on aluminum stubs with silver conducting paint, and coated with 150-Å gold/palladium (60:40). Micrographs were taken in an ETEC E-1 scanning electron microscope operated at 10kV.

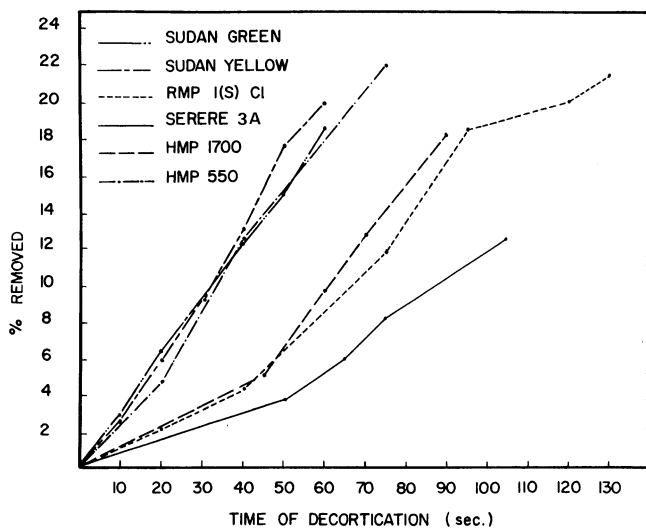


Fig. 2. Decortication of pearl millets at 1,800 rpm with a 60-mesh grit.

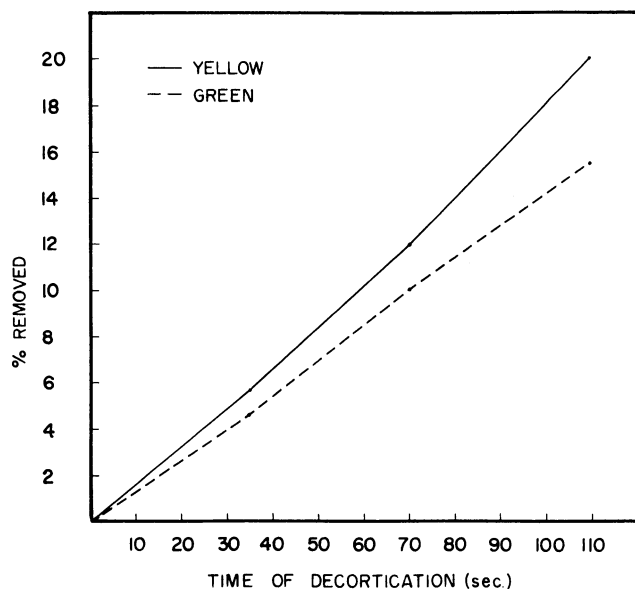


Fig. 3. Decortication of Sudan Yellow and Sudan Green millets with an 80-mesh grit and 1,500 rpm.

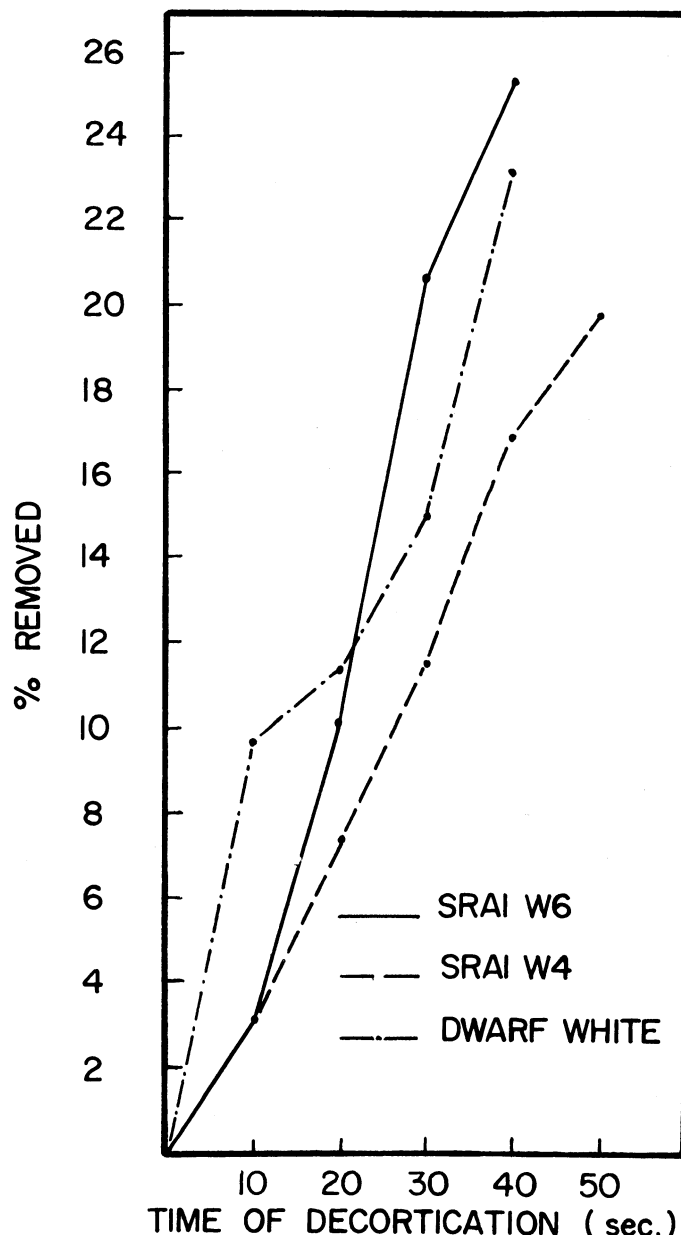


Fig. 4. Decortication of sorghum at 1,800 rpm with a 60-mesh grit.

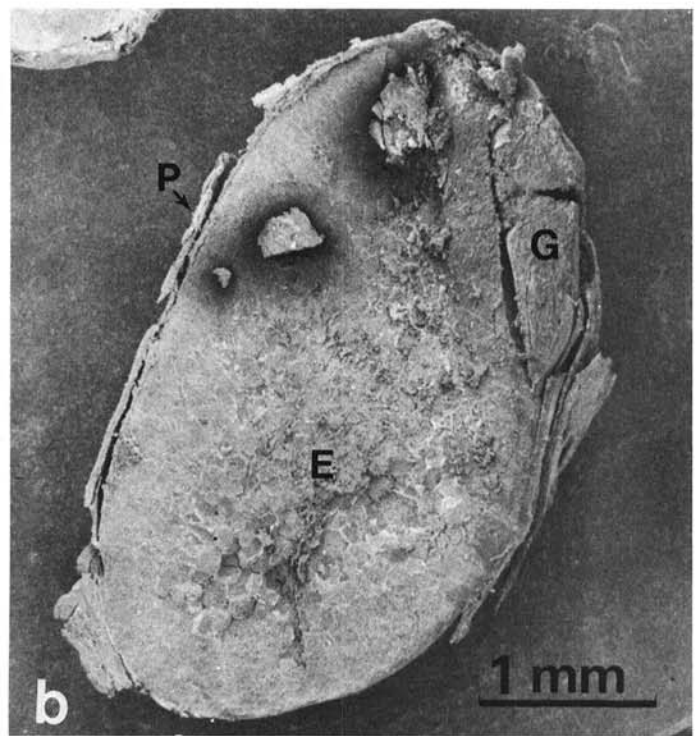
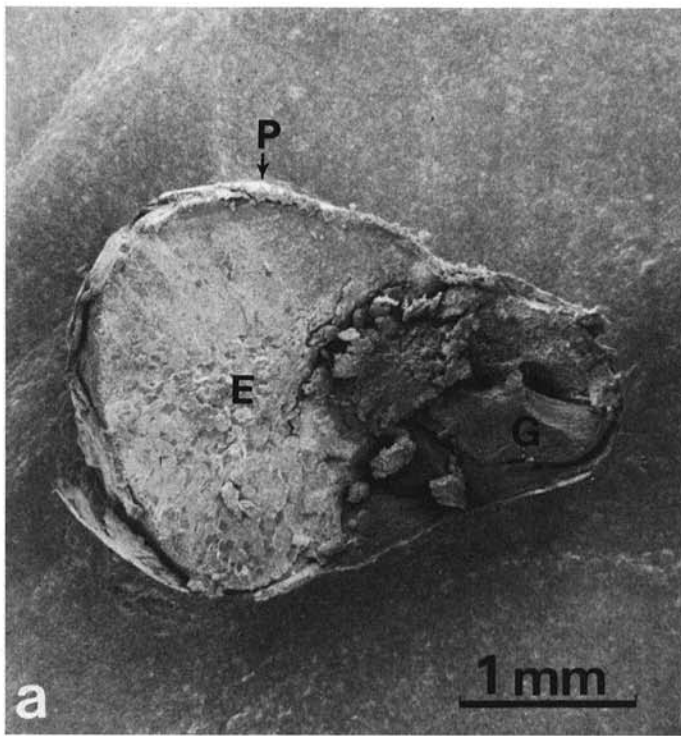


Fig. 5. Millet (a) and sorghum (b) decorticated to 12 and 6% extraction, respectively. P = pericarp, E = endosperm, G = germ.

Dye Studies

The decorticated grains were stained with a mixture of 0.05% methylene blue and 0.15% Eosin-Y in 70% ethanol to differentiate the tissues of the pericarp. The procedure was a modification of the method of Scheuring and Rooney (1979).

Fractionation of Processed Sorghum

The sorghum endosperm material—whole or decorticated grain and the decorticate—was fractionated using screens and a seed blower (South Dakota Seed Blower) as shown in Fig. 1. This fractionation technique permitted us to obtain precise estimates of the amount of "pure" bran removed from the kernels (bran uncontaminated by endosperm fragments) as well as of percentages of broken kernels resulting from decortication.

RESULTS AND DISCUSSION

Decortication

The amount removed from pearl millets during decortication varied considerably among populations (Fig. 2). The Serere 3A, HMP1700, and RMPI(S)CI required more time than the other samples to obtain the same level of decortication. Conversely, millets from Sudan were much easier to decorticate than the millets grown in Kansas, except HMP550. When we used less severe decortication conditions, Sudan Green took longer to decorticate than Sudan Yellow (Fig. 3).

The Udy cyclone mill has been reported (Shepherd 1979) to be useful in differentiating sorghum cultivars for ease of decortication. We found that the sorghum cultivar that required the shortest time for decortication (to 12% removed) was Dwarf White, followed by SRAI W6 and SRAI W4 (Fig. 4). Sorghum was more readily decorticated than millet.

Structural Studies

To determine why sorghum was more easily decorticated than millet, scanning electron microscopy was used. Photos of half-kernels of decorticated pearl millet and grain sorghum showed that the germ was largely retained in both (Fig. 5). The pericarp from millet was removed in small flakes (Fig. 6a), which readily passed a 1-mm screen. Conversely, the pericarp of sorghum was removed in large flakes during decortication (Fig. 6b). The pericarp for millet



Fig. 6. Flakes from decorticated millet (a) and sorghum (b).

was detached at the junction between the endosperm and the aleurone layer (Fig. 7a and c), whereas the sorghum pericarp's detachment point was in the starch-containing mesocarp (Fig. 7b and d). Millet mesocarp cells are devoid of starch granules, as

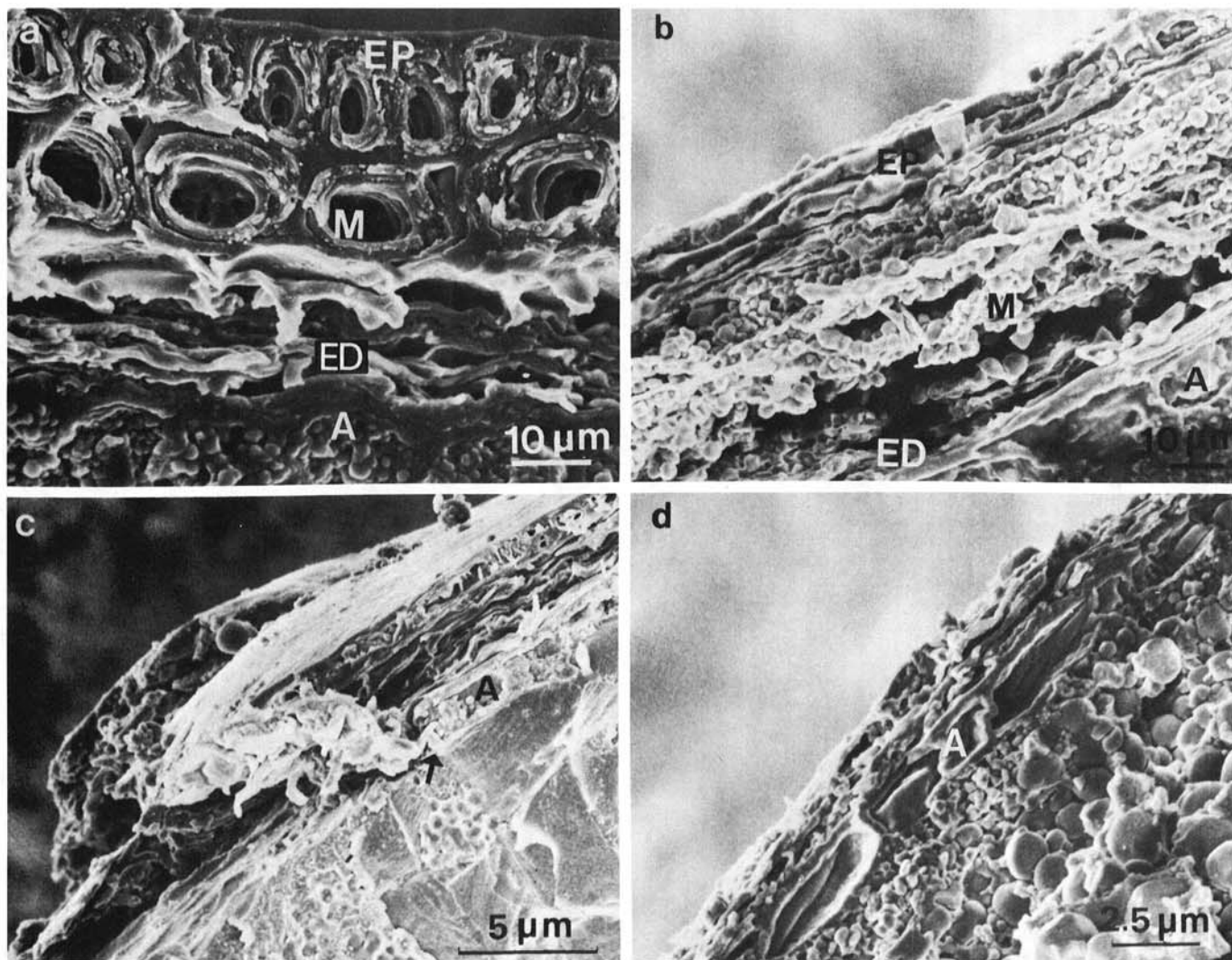


Fig. 7. Scanning electron micrographs of intact (a,b) and decorticated (c,d) grains: a and c, millet; b and d, sorghum. Arrow in c indicates point of detachment at junction between aleurone (A) and endosperm. EP = epicarp, M = mesocarp, ED = endocarp.

TABLE II
Fractionation of Decorticated Sorghums

Cultivars	Recovered Products (%)		Intact Decorticated Grain
	Bran	Brokens ^a	
SRAI W4	10.1 ± 0.05 ^b	5.0 ± 0.03	83.6 ± 0.03
SRAI W6	10.0 ± 0.05	7.3 ± 0.01	80.8 ± 0.15
Dwarf White	14.2 ± 0.04	43.0 ± 0.02	41.2 ± 0.20

^a Small and large.

^b Mean ± standard deviation of the mean.

Sullins and Rooney (1977) reported. Based on the data from scanning electron microscopy, we concluded that inherent structural dissimilarities of grain sorghum and pearl millet cause different decortication patterns.

Fractionation of the Decorticate

To explain differences in the amount of decorticate obtained with different sorghum cultivars, we classified the decorticate into bran, brokens, and intact decorticated grains, according to the fractionation scheme shown in Fig. 1. That procedure gave wide variations in the amount of brokens. Dwarf White, the cultivar with the most decorticate, had a higher percentage of brokens than any other sample (Table II). Differences in decortication behavior of sorghum cultivars are therefore related to "softness" of the

endosperm with Dwarf White having a softer endosperm than the other sorghums. The amount of bran removed ranged from 10.0 to 14.2% (Table II) in the three cultivars. Such wide variation may indicate genetic variation in amounts of starch in the mesocarp or in the thickness of outer pericarp layers.

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