separatory funnel, which was shaken manually for 30 s, and the phases were allowed to separate. The lower chloroform phase was drained off and retained. The extraction was repeated twice with 40-mL portions of chloroform. The combined chloroform extract was filtered through a No. 43 Whatman filter paper containing a teaspoonful of powdered anhydrous sodium sulfate (Na_2SO_4) into a 500-mL, round-bottom boiling flask. The combined extract was evaporated at 40 °C to ca. 10 mL. Each 10-mL sample was washed into a 25-mL volumetric flask with acetone to bring the volume to 25 mL.

Gas Chromatographic Analysis. Residues were determined with a Bendix 2110 X GLC equipped with a Bendix flame photometric detector. The GLC and detector were used with these conditions: column, 4 mm i.d. × 30.5 cm glass packed with 2% D.C. 200 and 2% QF-1 on Gas-Chrom Q 60–80 mesh, temperature, column 160 °C, injection port 190 °C, detector 160 °C; carrier gas, nitrogen 185 mL/min, hydrogen 150 mL/min, oxygen 25 mL/min, air 90 mL/min; volume injected, 4 μL of extract.

RESULTS AND DISCUSSION

Tables I, II, and III show methyl phoxim residues during the 30-day study. The corn, sorghum, and wheat were analyzed immediately after treatment and found to contain deposits from 9.9 to 10.3, 9.9 to 10, and 9.7 to 10.1 ppm, AI, respectively. After 30 days of storage 77.1, 90, and 97% of the initial deposits disappeared from 20% moisture corn, sorghum, and wheat. Apparently higher moisture content does not accelerate residue degradation on corn compared with sorghum and wheat. Twenty-four hour methyl phoxim residues in wheat were much lower than in corn and sorghum above 10% grain moisture level. Residue loss increased in all grains with increase in moisture content. Methyl phoxim residues in corn, wheat, and sorghum decreased gradually with 22.9, 10, and 3% of the initial deposit remaining on the 20% m.c. grain, respectively, after 30 days of storage. Methyl phoxim residues were markedly reduced when the moisture content of all grains was increased to 20%. However, the residue recovered from the lowest moisture content of the grain (6%) was the highest at all intervals during the 30 days.

Cleaned grain of low moisture content retains sufficient methyl phoxim residue to resist most stored-grain insects (Alnaji et al., 1977; McDonald and Gillenwater, 1976). These results coincide with observations of Kadoum and LaHue (1969, 1975), viz., increased moisture content of grain enhances malathion degradation; however, degradation of methyl phoxim is less in corn and sorghum than in wheat. Kadoum and LaHue (1972) reported that the biological activity of live sorghum kernels enhances breakdown; hence, age of grain, moisture content and physical characteristics may influence retention of residue in the grain.

The average moisture content of the samples of corn and wheat from the western part of the state, when collected, averaged ca. 11.1 and 10.6%; that from the eastern part averaged 13.1 and 12.9% for the corn and wheat (LaHue, 1976). Rapid rate of degradation on corn up to 14 days with less rapid decrease up to 30 days was observed. On sorghum the rate of decrease in residue is rather sharp up to 14–21 days also. On wheat the degradation follows a more gradual trand. This is especially true at the higher moistures.

Hence, these data can be used effectively to establish rate of application to grain harvested and stored under adverse moisture conditions. Our study can be applied to storing and marketing treated grain, predicting the methyl phoxim level in stored sorghum, corn, and wheat so dosage can be biologically effective (Alnaji, 1977) for extended storage periods.

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Cucurbit Root Starches: Isolation and Some Properties of the Starch from *Apodanthera undulata* Gray

Starch has been found in the roots of the feral xerophytic gourd *Apodanthera undulata* Gray. This perennial is well adapted to marginal agricultural lands of semi-arid and arid environments. The starch can be readily isolated from the large storage roots. It has an iodine affinity value of 5.01, and the granules have an average diameter of 17 μm and resemble tapioca starch granules in appearance.

The potential of wild perennial gourds indigenous to western and southwestern United States as oilseed crops was first suggested by Curtis in 1946. Interest in xerophytic cucurbits has increased with additional studies and growing water shortages (Shahani et al., 1951; Bemis and Whitaker, 1969; Jacks et al., 1972). Three species, *Cucurbita foetidissima*, *Cucurbita digitata*, and *Apodanthera undulata*, are currently being investigated at this Univ-

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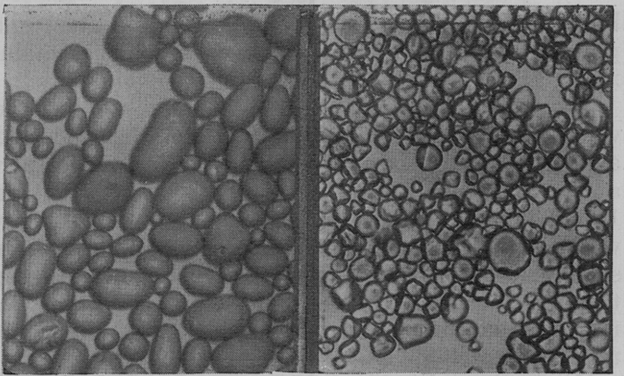

Figure 1. (Left) starch from root of *A. undulata* (358X); (right) starch from Idaho potato (358X).

ersity. These gourds are well adapted to marginal agricultural lands of semi-arid and arid regions, and they produce seeds rich in oil and protein (Bemis et al., 1975; Berry et al., 1976; Weber et al., 1977). In addition, the extensive storage roots of the two *Cucurbita* species are known to contain starch in high concentration (Berry et al., 1975).

We wish to report here that starch is also a major component of the roots of *A. undulata*, a gourd which ranges from western Texas to southern Arizona and northern Mexico and is somewhat unusual in producing soft mellonlike fruit in place of a hard shelled gourd. It develops a relatively large storage root with a length of about 1 m. The isolation of the starch and some of its properties are described below.

PROCEDURE

Roots of feral plants were dug near Tucson, Arizona during May 1977. They were peeled, sliced, and ground for 2 min in replications of 300 g in 2 L of water using a 1-gal Waring blender. The slurry was filtered through a 150-mesh screen, and residues of several operations were combined and reground in fresh water. Filtrates were combined, filtered through fine muslin, and collected in a tall glass cylinder. The dispersed starch was allowed to settle at 4 °C for 2–3 h and then redispersed in fresh water. This sequence of dispersal, settling, and redispersal was followed three times. The suspension was then centrifuged at 1000 rpm in 250-mL bottles, and the low density fibrous contaminant was scraped from the surface. This was repeated six times until the starch was free of fiber. The starch was then suspended at 27 °C three times in methanol and once in acetone to aid in water removal, filtered, dried at 40 °C in a vacuum oven, and equilibrated with atmospheric moisture.

Chemical and physical properties were determined by the methods of MacMasters (1964), Schoch (1964), and Smith (1964). Potato starch was prepared by the method of Schoch (1957) from Idaho potatoes (russet Burbank).

RESULTS AND DISCUSSION

The yield of moisture equilibrated starch (water content 11.5%) was 23% based on the dry weight of the root. The moisture content of the fresh root was 66%.

Photomicrographs of granules of the cucurbit *A. undulata* root starch and potato starch are shown in Figure 1. The cucurbit starch granules have diameters ranging from 6 to 42 μm with an average of 17 μm. They resemble tapioca starch in that many are truncated, and a centric hilum is readily seen in many granules under a magnification of 358X.

Table I. Analytical Values for Xerophytic Cucurbit Root Starches

Analysis, %	*A. undulata*	*C. digitata*[a]	*C. foetidissima*[a]
Moisture	11.47	8.78	6.18
Protein	0.24	0.45	0.85
Fat	0.63	0.50	0.57
Ash	0.17	0.17	0.12
Iodine affinity	5.01	4.42	4.07

[a] Data from Berry et al. (1975).

The gelatinization temperature was determined to be 64.5–67.5 °C by observation of staining with Congo Red. Gelatinization temperatures very close to this range have been reported for other cucurbit starches (Berry et al., 1975; Reichert, 1913).

Analytical data for this starch and the *Cucurbita* root starches are presented in Table I. The iodine affinity value indicates a low amylose–amylopectin ratio similar to that of most other root and tuber starches.

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