

A Single-fruit Seed Extractor for Cucumbers

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Summary. The construction of a single-fruit seed extractor for cucumber is described. It increases the speed and ease of removing seeds from individual, mature cucumbers for later drying and planting. The machine saves about 47 seconds/fruit compared to hand methods and is suited to handling single fruit (or batches of up to 50) by researchers needing seeds from controlled pollinations. In 5 years of use, no reduction in seed recovery or germination has been observed using the seed extractor relative to hand harvest.

Plant breeding and biotechnology research on cucumber (*Cucumis sativus* L.) often requires that mature fruits be harvested for seed recovery from controlled pollinations. We built and modified four single-fruit seed extractors at North Carolina State Univ., two of which are used currently by the cucumber breeding program in the harvest of over 2200 fruit produced by controlled pollination each season. The machines increase the speed of seed harvest and save labor costs compared to the hand extraction methods previously used.

The single-fruit seed extractor was built by the Biological and Agricultural Engineering Shop at North Caro-

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Fig. 1. Single-fruit seed extractor for cucumbers.

lina State Univ. modeled after a machine built by Leonard M. Pike (Texas A&M Univ., College Station). Our first extractor (Fig. 1) subsequently was modified to make it more durable, easier

to maintain, and quieter. Some of the changes made include the use of aluminum and stainless steel to prevent rust, the addition of foam insulation inside the hood for quieter operation, the use of bearings with a grease fitting for lubrication after each harvest season, and the replacement of the three wires on the auger with three fins (or vanes) to

make the auger less likely to fail.

Related machines. Cucumber seed harvest has become more mechanized in the last few years following the design of machines such as the seed sluice for small plots (Steiner and Letizia, 1986) and the bulk seed extractor (Wehner et al., 1983). The single-fruit seed extractor is similar in purpose to the bulk seed extractor, but operates on a different principle. The bulk seed extractor (suitable for large quantities) crushes the fruit, creating a large amount of pulp. After using the bulk extractor in a field isolation block, the mound of pulp and fragments of discarded fruits can be disked into the field. In contrast, the single-fruit seed extractor bores into the end of the fruit, leaving the fruit mostly intact for easy disposal from the greenhouse or laboratory where the extractor often is used.

Description. The essential components of the single-fruit seed extractor are the extractor cone (or auger) for excavating the seed cavity and a means to drive it, a pail or containment

Fig. 2. Schematic diagram of frame and component parts of single-fruit seed extraction.

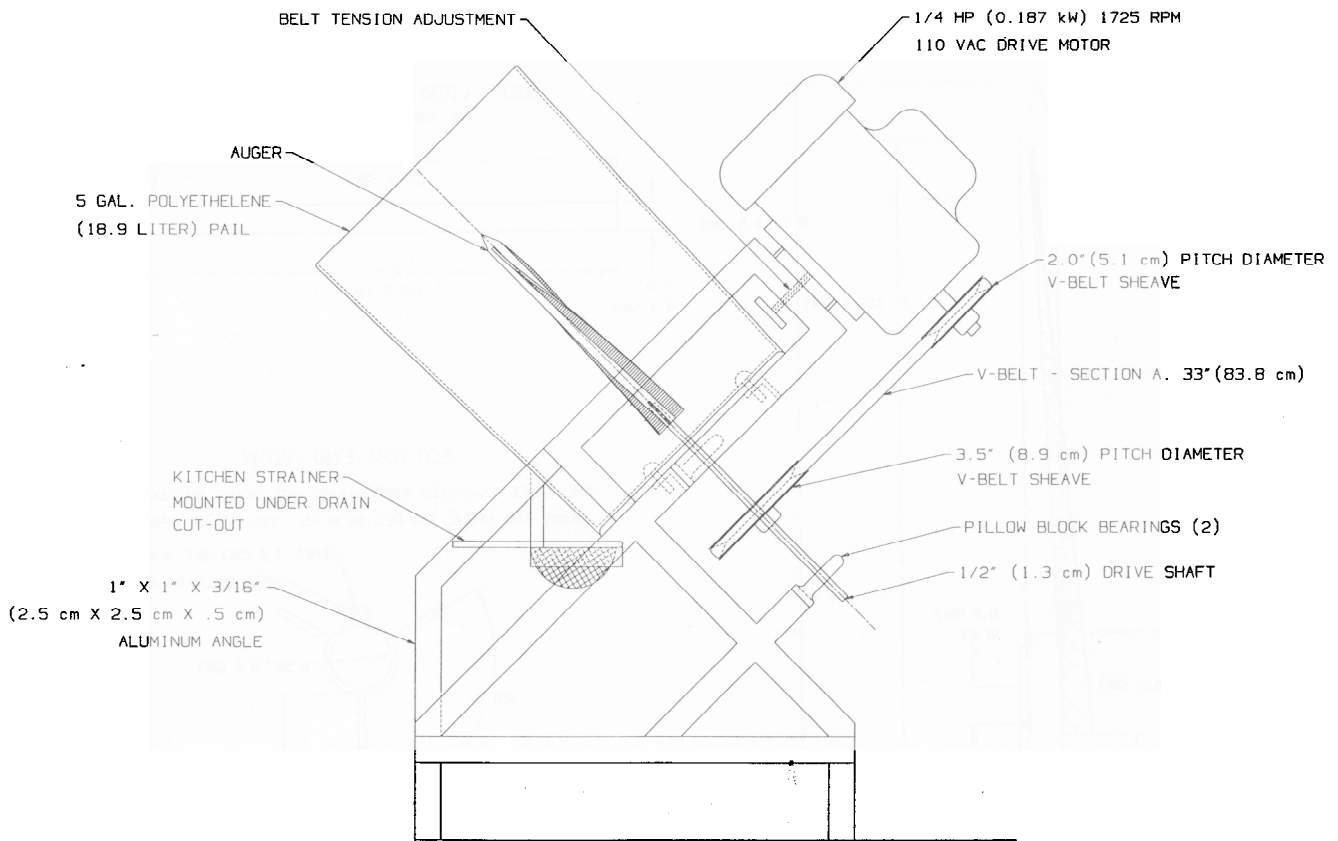


Table 1. Parts list and cost for constructing a single-fruit seed extractor for cucumber.

No.	Description	Cost (\$)
2	Pillow blocks (bearings)	29.76
1	2-inch pitch diameter, A or 4L section sheave, 0.5-inch bore	4.20
1	3.5-inch pitch diameter, A or 4L section sheave, 0.5-inch bore	8.99
1	Belt (A33)	3.91
1	Electric motors 1725 RPM, 0.25 HP, 115 volt AC	90.40
1	Floor switches (Clipper Cat. No. 632-SC3)	31.36
1	Extra cord	18.71
1	1 × 1 × 3/16 × 648-inch aluminum angle	89.71
1	0.5 × 12-inch stainless-steel drive shaft	3.55
1	5/8 × 12-inch stainless-steel drive shaft	5.54
1	3/16 × 60-inch stainless-steel rod	2.63
1	5-gallon (18.9-liter) pail	0
1	Hose	8.00
1	Nozzle	10.00
1	Tea strainer	5.00
1	Tub silicon caulk	5.89
1	Polystyrene insulation board	9.50
1	Screws and accessories	15.00
1	48 × 96-inch (1.2 × 2.4 m) sheet stainless steel	100.00
Labor (19 h × \$20)		380.00
Total		\$822.15

*Costs are based on 1993 prices in Raleigh, NC.

vessel to collect the seeds, a strainer, and a suitable frame for support (Fig. 2). In addition, it is useful to have access to a water line with a nozzle

Fig. 3. Details of auger construction illustrating one of three vanes attached to the center cover.

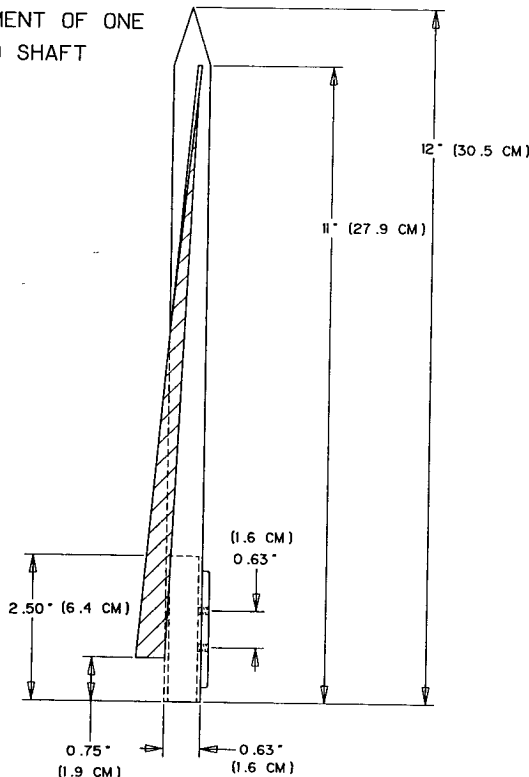
(pistol grip garden hose type is adequate) for flushing out the seeds and pulp from the pail. The tea strainer is an ordinary screen-wire kitchen type (diameter about 6 inches or 150 mm). A foot-operated on-off switch for the drive motor is recommended to free

both hands of the operator for other tasks. The cost of construction, including labor and the component parts and materials, was more than \$800 in 1993 (Table 1). Costs would be less if the aluminum and stainless-steel materials were replaced with less-expensive alternatives and labor from within the project was available.

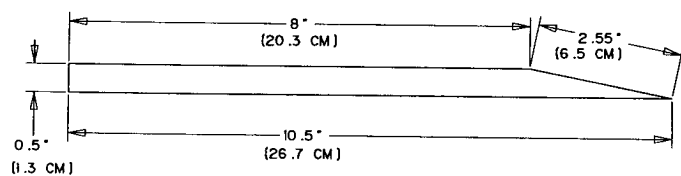
The single-hit extractor unit is 34 inches high x 12 inches wide x 26 inches deep (864 x 305 x 660 mm). The frame design (Fig. 2) is simple: the main consideration is supporting the motor, pail, and drive shaft at an inclination of about 45° to facilitate draining and wash-out. Ideally, the frame should fit inside a sink or some other drain-equipped fixture to dispose of the wash water conveniently. Frame members are 1 × 1 × 3/16 inch (25 × 25 × 4.76 mm) aluminum angles welded together to form a rigid support. Stainless-steel angles also would be suitable, but mild steel is not recommended since the unit is frequently wet.

The 0.5-inch (12.7-mm) diameter drive shaft is supported by two self-aligning pillow block bearings and is driven by an A-section V-belt via a 0.25-horsepower (0.187-kW), 115-V-AC, 1725-rpm electric motor. The drive shaft also must be supported

ATTACHMENT OF ONE VANE TO SHAFT

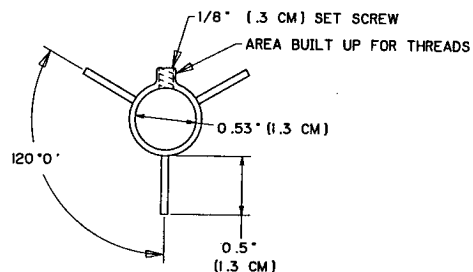


SIDE VIEW OF VANE (3 REQUIRED)
THE THICKNESS OF THE VANE IS 16 GA.



BOTTOM END VIEW

THE THREE STAINLESS STEEL VANES ARE SPACE 120 DEG. APART AND SPIRAL 120 DEG IN 10.25" (26 CM) OF SHAFT LENGTH



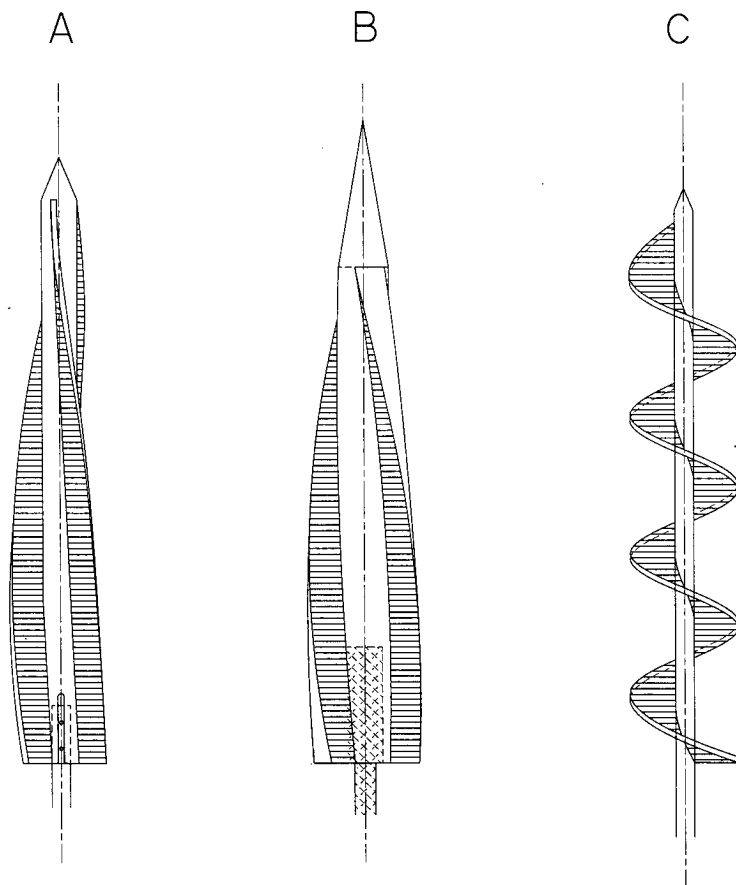


Fig. 4. Schematic of three different augers; A is the original three-vane stainless steel auger; B is constructed in a similar manner from PVC materials; and C is a commercially available soil-boring tool having a single vane or blade. All three augers are approximately the same size.

axially to resist the thrust loads as fruit are pushed onto and removed from the auger. Thrust loads are relatively small, and the bearings can absorb them provided the bearings are securely locked to the drive shaft. Motor speed is reduced by the 2.0/3.5 sheave ratio to drive the auger at 986 rpm. Evaluation at other speeds indicated that an auger speed as low as 600 rpm also might be satisfactory.

Torque requirements on the auger drive shaft varied as a function of fruit maturity and rate of feed. We did not encounter torque levels above 15 inch-pounds (1.7 Nm). The drive motor was mounted on a hinged plate that allowed adjustment of tension in the drive belt. Belt tension should be maintained at a level just sufficient to drive the auger; higher belt tension increases the likelihood of injury to the operator if hand, arm, or clothing should become entangled with the auger.

A rigid coupling with two set screws

at each end is attached to the base of the auger core shaft (Fig. 3) to attach the auger to the end of the drive shaft after its assembly through the bottom of the pail. It is important to mount the 5-gallon (18.9-liter) polyethylene pail rigidly to the frame to maintain alignment of the drive shaft and the center hole in the pail.

The stainless-steel auger (Fig. 3) was the most difficult component to fabricate. Three vanes constructed from 16-gauge stainless steel were attached in a spiral to a 0.625-inch (16-mm) diameter stainless-steel core shaft, 12 inches (305 mm) long. Each vane spiraled 120° from its base to its tip and

was welded (noncontinuous fillet) to the core. The core shaft was cone-tipped (Fig. 4) to provide easy penetration of the fruit. The base of the core shaft was drilled-out 2.5 inches (63.5 mm) deep to accept the 0.5-inch (12.7-mm) diameter drive shaft. Bending the vanes and attaching them uniformly to the core to form a balanced auger required more than novice skills in metal fabrication. Silicon caulking, or something more durable, should be used to seal any gaps between the vanes and core that might trap seeds and permit them to be mixed with subsequently processed fruits.

The frame, motor, and drive components were enclosed with a 22-gauge stainless-steel sheet (Fig. 1) undercoated with 0.5-inch (12.7-mm) thick extruded polystyrene insulation. Those steps were taken to protect the electrical connections and motor from inadvertent wetting by the wash-out nozzle and to dampen the noise of the drive components. Proper grounding of the electrical system is required. In addition, a ground fault interrupter should be used in the circuit to eliminate the possibility of shock.

Operation. Fruit are harvested 4 to 7 (usually 6) weeks after pollination and are allowed to age up to 3 days. The seeds are extracted from one fruit at a time, the bucket and auger are washed clean of seeds using a hose with a nozzle, and the seeds are collected in a kitchen-type tea strainer under the bucket. Next, the seeds are washed using a blast of water from the hose, light seeds are floated over the top of the strainer in a bucket of water in the sink, and the remaining seeds are washed again using a second series of water blasts from the hose. Finally, seeds are placed in a 100-mm-diameter, plastic petri plate bottom (the shallower lid is not used). Seeds in

Table 2. Time required for each operation of seed extraction from cucumbers using hand (knife to cut fruit, spoon to remove seeds) and machine (single-fruit extractor) methods^a.

Method	Operation	Time (sec/fruit) for fruit lota					Mean
		1	2	3	4	5	
Hand	cut	45	45	50	50	50	48
	Extract	15	20	15	15	15	16
	Wash	85	90	90	125	115	101
	Total	145	155	155	190	180	165
Machine	cut	0	0	0	0	0	0
	Extract	15	20	20	20	15	18
	Wash	70	65	115	145	105	100
	Total	85	85	135	165	120	118

^aData are means of five lots of fruits measured for the three operations required for seed extraction.

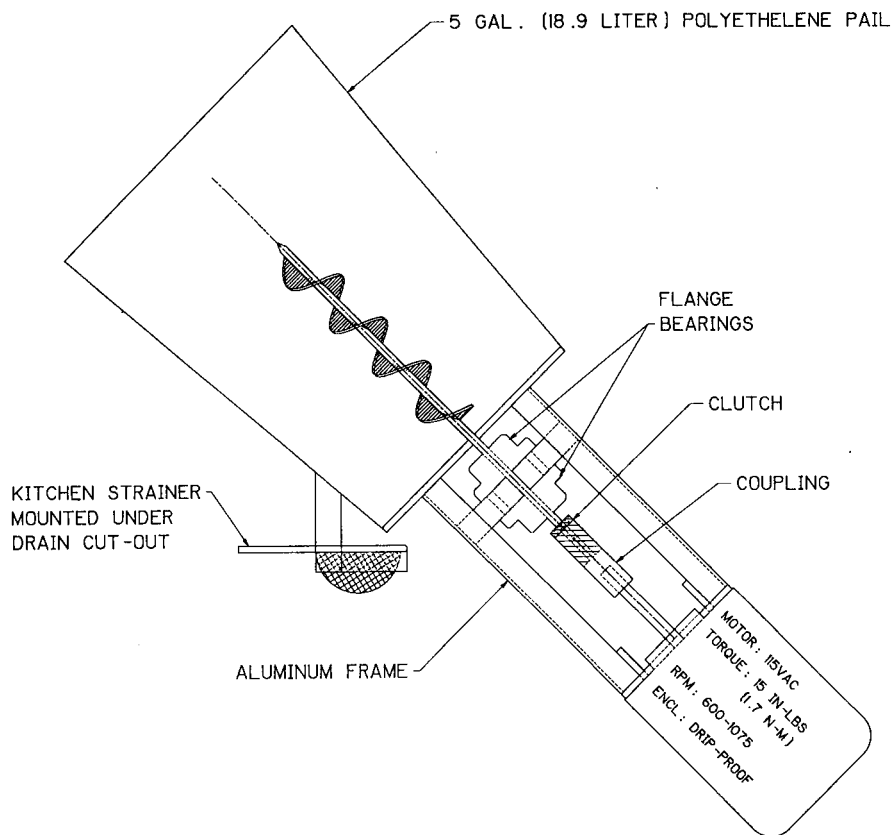


Fig. 5. Schematic of an experimental direct-drive unit that also uses a slip clutch between the drive motor and seed extractor auger.

petri plates are held in a screen-bottom tray in a seed dryer and dried at 30C. After drying, the seeds are placed in coin envelopes for storage.

The time required for extraction was 15 to 20 sec/fruit (mean of 18) and 60 to 150 sec/fruit (mean of 100) for washing, averaging 120 sec/fruit. Washing times of 60 to 80 sec/fruit were possible if the fruit had been off the vine for 1 or more days. Fruit held at room temperature after harvest begin enzymatic breakdown of tissue so that seeds separate easily from the placent during extraction and washing. Harvesting fruit from plants and drying of seeds from the extraction process required additional time.

Some plant breeders harvest fruit more than 1 week before extraction to permit cleanup of the cucumber plants and replanting the greenhouse. Since the seeds apparently are continuing to mature in the detached fruit, the overlap permits a shorter generation time in the greenhouse.

The hand method of seed extraction involved cutting the fruit open longitudinally with a knife, scraping the seeds out with a spoon, and washing them in a tea strainer under a water

spray. Time required for hand extraction was 140% that of the machine method (Table 2). Hand washing (65 to 145 sec/fruit, mean of 100) required about the same time as machine extraction (85 to 125 sec/fruit, mean of 101), so the major gain was made in seed removal, which required 60 to 65 sec/fruit (mean of 64). With the hand-extraction method, it required 45 to 50 sec/fruit (mean of 48) to cut a fruit open, and 15 to 20 sec/fruit (mean of 16) to remove the seeds. With the machine, only 18 sec/fruit were required to cut into the fruit and remove the seeds in a single operation.

Seed extraction from single fruit using hand vs. the machine showed that the machine extractor saved 47 sec/fruit. That saving amounts to 89 h (11 worker-days) per year for our three crops of 2268 fruits each.

Performance. The single-fruit seed extractor has been used for 5 years without problem and without injury to the operators. The percentage of seeds recovered from single fruit, and the germination speed and percentage were apparently unaffected by the single-fruit extractor. However, we recognize that the extractor could be simplified with regard to construction, especially the auger. Also, improvements related to safety are necessary for general use. Modifications to the

unit to address those concerns have been considered and to a limited extent evaluated.

We were able to simplify construction of the auger by using polyvinyl chloride plastic (PVC). The core was a length of 0.5-inch (13-mm) schedule 80 PVC pipe, and the vanes were 0.5 × 0.5-inch (12.7 × 12.7-mm) square PVC bars (Fig. 4). Hot-air PVC welding methods were used to attach the vanes to the core. The auger tip was formed in a lathe from solid, round 0.75-inch (19-mm) diameter PVC stock and attached to the pipe core with PVC adhesive. The base of the auger core was fitted with a steel insert to allow its attachment to the drive shaft. The PVC auger was tested briefly and it performed similarly to the stainless-steel auger extracting seeds and pulp. The vane edges were beveled 0.0625 inch (1.6 mm) and were considerably less likely to injure the operator's hand compared to the 16-gauge, stainless-steel vanes.

A third auger was tested to improve the simplicity of construction. It consisted of a commercially available soil-coring tool manufactured by JISCO and available at nursery outlets. It had a single flight or vane of 14-gauge alloy steel spirally wound on a 0.3 125-inch (8-mm) diameter core with a 2-inch (51-mm) pitch to form a 1.5-inch (38-mm) diameter auger (Fig. 4). We modified the ends of the unit and its length to mount it to the drive shaft of the extractor. The auger, requiring the least amount of fabrication as a seed extractor, also performed satisfactorily in limited tests.

The primary safety concern regarding the extractor was the potential contact of the operator's hand with the rotating auger, or the possibility of catching and wrapping loose clothing in the auger. Short sleeve shirts or blouses are recommended, and rings, wrist watches or other accessories should not be worn when operating the extractor. Additionally, a safety feature to disengage the unit from its power source when it encounters out-of-the-ordinary conditions should be considered. To this end, we installed a slip clutch on the drive shaft of a modified unit (Fig. 5).

The in-line clutch (model JJ-28; W.W. Berg) was adjusted to slip at torque levels from 11 to 187.4 inch-ounces (0.0779 to 1.33 Nm) by varying the spring pressure applied to the clutch surfaces. Shaft bore size was

limited to 0.3125 inch (8 mm) and modifications of the drive shaft to include a rigid step-down coupling were necessary. Note that the drive motor was positioned to an in-line position, thereby eliminating the V-belt drive (Fig. 5). In that configuration, a motor should be selected with a rotational speed of 600 to 1000 rpm. The clutch unit, although rated at < 240 inch-ounces (1.7 Nm, previously determined), was successful in driving the

JISCO auger in limited tests. More importantly, the clutch mechanism allowed one to grasp the auger and stop it by hand. Its inclusion (or a similar unit) in the drive train as an in-line component, or mounted directly to the motor shaft in an indirect drive mode, should be considered by potential builders and users of the extractor.

Plans. Working drawings of the single-fruit extractor will be supplied by T.C. Wehner upon request.

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