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A NEW CASTOR-BEAN SHELLER

By

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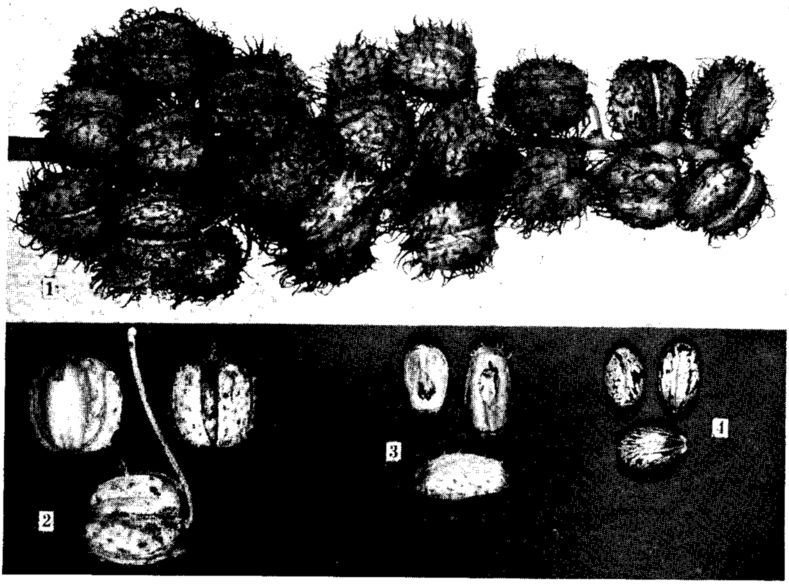

Stages in castor-bean shelling
1, Spike, or cluster. 2, Capsules, each containing three beans. 3, Individual beans, in shell, from one capsule. 4. Shelled beans, with seed coat intact.

KNOXVILLE, TENNESSEE

SUMMARY

1. The emergency need for domestic castor-bean production has been recognized by the Federal Government. Because of lack of importation facilities, and the increased use of castor oil in war materials, an acute shortage of the oil seems probable.

2. Recent commercial developments in the dehydration of castor oil for use in paints and varnishes have increased materially the production and consumption of castor oil and the importation of castor beans.

3. Hand harvesting has limited domestic production. For economical or emergency production, improved equipment is essential. Combines have been used for gathering castor beans from the stalks in the field. After curing, the beans can be shelled.

4. A new type of castor-bean sheller, incorporating new shelling principles, has been developed at the Tennessee Agricultural Experiment Station. The advantages of this sheller are as follows:

a. Will handle small clusters and capsules, as well as individual seed.

b. Simple and inexpensive in construction, although semi-automatic in feeding.

c. Easily adjusted for different varieties, and not critical in adjustment.

d. Shells a very high percentage of castor beans with very little, if any, injury.

e. Shells and cleans the beans in one operation, and conveys all dust away from the operator.

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Castor beans, as a source of castor oil, have been produced in this country in comparatively small commercial quantities only, according to Crooks and Sievers (2) and Shrader (11). Miller (7) observed that laborious and expensive hand-harvesting practices were an economic factor that limited production.

The problem of shelling castor beans gathered from experimental plots, the difficulties involved in shelling with a combine, the authors' experience with disk-type seed scarifiers, and the cooperative arrangements for the development of farm equipment as provided by the Tennessee Valley Authority and The University of Tennessee Agricultural Experiment Station, led to the development of a castor-bean sheller incorporating new shelling principles.

CONSUMPTION OF CASTOR OIL

During the first World War, castor oil was used as a lubricant for airplane engines. Judge (5) reports: "Castor oil, on account of its excellent 'oiliness' is still employed for the purpose of running in new engines for the first few hours of their operation . . . . " Why other oils are generally preferred for operating these engines at high speed after they are "broken in" is explained by Dentilhac (3). Because castor oil does not affect rubber, is relatively constant in viscosity, and possesses other unique properties, it is important as a fluid, or lubricant, for hydraulic brakes, shock absorbers, and recoil and other mechanisms. Furthermore, it is employed in the manufacture of many essential as well as minor commodities, such as dyed fabrics, artificial leather, artificial rubber, soaps, and special inks, as mentioned by Crooks and Sievers (2), Shrader (11), and Sethi (10). Comparatively new uses of the castor bean plant, as sources of insecticide and cellulose, as described by Hale (4), are found by Crooks and Sievers (2) so far to be unimportant commercially.

Austin (1) finds that recent commercial developments in the dehydration of castor oil for use in paints and varnishes have increased materially the demand for castor beans and oil. Because of new processes for rendering the oil suitable for high-grade paints and varnishes, Miller (7) a year ago predicted "a tremendous industrial market for this oil." The imports of castor beans increased from 162,610,861 pounds in 1939 to 237,788,672 pounds in 1940 and 343,198,000 pounds in 1941. In the same years, the domestic production of castor oil increased from 78,605,782 pounds to 99,972,205 pounds and 155,143,000 pounds, and the consumption of oil from 41,137,725 pounds to 54,003,392 and 89,890,000 pounds (8). Thus the imports of beans increased 46 percent in one year and 111 percent in two years; the production of oil, 27 and 97 percent; and the consumption of oil, 32 and 118 percent during the same periods. About 162,000,000 pounds of beans—almost the entire 1939 supply—came from Brazil.

Shrader (11) calls attention to the wide distribution of the plant in temperate and tropical climates. Prior to 1919, however, India supplied most of the castor beans used in this country. Masur (6) reports that prior to 1929 India had a virtual monopoly of the supply of castor beans to the United States and the United Kingdom. The supply from Brazil is rather recent, but Austin (1) predicted that it would be ample. Dry weather, absorption of cheap labor, and lack of shipping facilities may curtail the supplies in 1942 and later. With the shortage in supplies of tung, perilla, palm, and other oils, castor oil may become increasingly important.

The U. S. Department of Agriculture, as announced by OPD (9), started an emergency castor-bean production program in June 1941, to furnish a supply of adapted seed stock for 1942. The program was limited to about 1700 acres in Texas. The farmers received 3½ cents per pound for these beans, with conservation deductions exempted. Other emergency plantings are reported by Staples (12). Crooks and Sievers (2) report a 1940 commercial production in this country—the first in many years.

PRESENT HARVESTING METHODS

One method of harvesting, mentioned by Crooks and Sievers (2), is to "cut off the spikes with a knife and throw them into a wagon or a box sled." Miller (7), referring to a certain shatter-resistant, or non-popping, castor bean, makes the following observations: "When seed clusters average about 8 oz. of beans, it is possible for one man to pick 50 to 60 bu. of threshed beans in a normal working day. The cost of this operation in this case is comparable to picking corn by hand. A machine for doing this operation is much desired. . . . The threshing is probably best done by passing the beans between two rubber-covered rollers, one running about 50 percent faster than the other. These rollers should be spaced so that they cannot come any closer together than the thickness of the seed, because it is absolutely essential that the seed be not damaged, in order to obtain a high grade oil." Another method of shelling, mentioned by Sethi (10) as used in India, seems to be a retting process. The castor beans or clusters are placed in a pit with suitable organic material, and after the shell has decomposed sufficiently the beans are removed and washed.

FACTORS AFFECTING DESIGN OF EQUIPMENT

Some varieties are naturally better adapted for mechanical harvesting than others. In regard to "popping" varieties, Miller (7) says, "Obviously such varieties cannot be grown commercially in this country. Before any variety can be considered, it must yield well; the seed must have a high oil content; the seed clusters must be large, and it must be shatter resistant to the extent that it will be possible to leave the seed on the plant and harvest all of it at one time after frost."

Care must be taken not to injure the seed coat when harvesting, hauling, or shelling. Shrader (11) explains that "Castor beans also contain the enzym lipase, which is extremely active in hydrolyzing the oil to glycerin and free fatty acid. This action does not occur so long as the seed coat remains intact and protects the kernel from exposure to the air, but when the seed coat is broken the enzym quickly begins its hydrolytic action. Since broken and damaged beans when crushed yield a highly colored acid oil, care must be exercised in hulling and shipping to avoid breaking the seed coats."

The poisonous properties of castor beans also may have an important bearing on the design of equipment. As stated by Crooks and Sievers (2), "The castor bean is known to contain two poisonous constituents. One, a very toxic albumin called ricin is present in the non-oily portion of the bean and is responsible for the poisonous nature of the press cake or pomace. . . . The other poisonous substance, which is called ricinine, is of an alkaloidal nature and occurs in other parts of the plant as well as the seed. Little is known regarding its toxicity, and there appears to be no published record of losses of stock from eating the foliage."

MECHANICAL HARVESTING

In 1941, a 5-acre field of castor beans, located near Knoxville, was harvested with a combine. The variety was reported as "Connor," a low-growing, non-shattering, small-seed type. Unless special shelling equipment is used, it is difficult to prevent injury to the beans. Indications are that combines, with minor modifications, may be used to collect the seed from certain low-growing, non-shattering varieties if no attempt is made to remove the beans from the capsules. Unless easy-shelling varieties are available, it appears that the combine can be used only to collect the clusters of seed from well-matured plants. After curing or drying, the seed can be shelled more efficiently with special equipment.

From the agronomic viewpoint, combining, besides saving labor, should eliminate the requirement of large seed clusters, as pointed out by Miller (7).

NEW SHELLING PRINCIPLE

Recently, at the Tennessee Station, a new principle in the shelling of castor beans was developed. When pressure is applied to the sides of a shell with sufficient force to remove the shell, the bean usually is injured or crushed. If the pressure is applied to the ends, the shell is easily removed without injury to the bean. A sheller was constructed that utilizes this principle.

DESCRIPTION OF A NEW CASTOR-BEAN SHELLER

The machine consists essentially of two adjacent rubber-faced disks. One of the disks, fastened to a feed hopper, is stationary; the other, attached near the end of a shaft, is rotated at a peripheral speed of about 1570 feet per minute, or approximately 1000 revolutions per minute for a 6-inch disk. For convenience, a polishing head was used as a shaft mounting. Glue and tacks hold the rubber facings on plywood disks. The stationary disk and hopper as

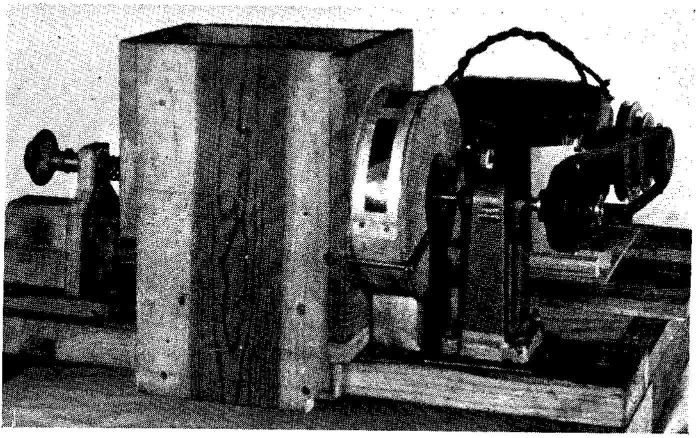

Fig. 1—Castor-bean sheller assembly without cleaner

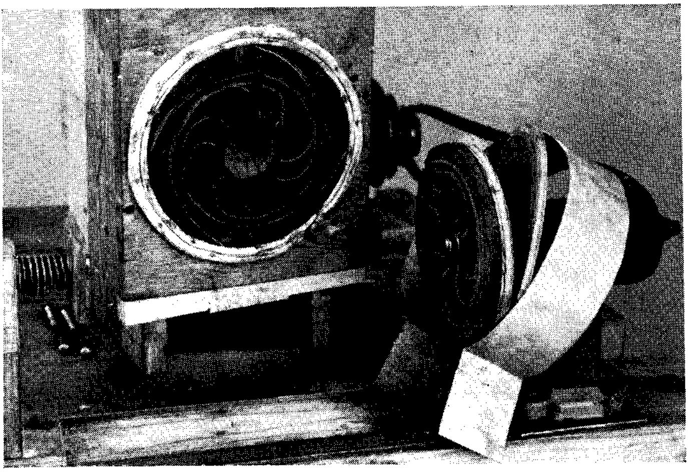

Fig. 2—Sheller disassembled to show shelling disks

a unit slide on a base, being pushed toward the rotating disk by a spring, and held from going too close to it by the bolt which extends into the hopper (see figures 1 and 2). The disk has a centrally located feed opening from the hopper—or it may be slightly off center to facilitate feeding. Spacing between disks is adjusted by moving the hopper part so that the shelled bean will fit easily endwise between the rubber faces. A metal housing directs the beans and shells downward through an opening in the base. V-shaped grooves, shown in figure 2, are cut in the faces of the rubber disks. These grooves are about 3/16 inch in width and depth, near the center, and decrease in width and depth as they extend outward in a spirally curved path. Beans that enter through the opening near the center of the stationary disk are moved outward by the rotating disk. Apparently, the curving of the grooves in opposite directions causes the beans to rotate in more than one plane. Beans that happen to enter sidewise are turned so that the pressure comes on the ends. As the space between the disks is equal to the length of the shelled beans, the beans in the shell must be rotated endwise between the disks for shelling. The beans cannot be injured unless several are wedged together.

Some beans drop down between the disks, lengthwise, without being shelled or picked up by the grooves. To increase the shelling

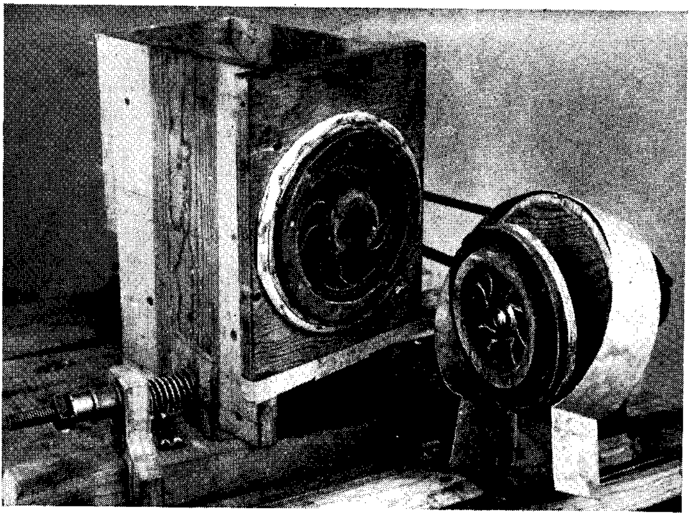

Fig. 3—Sheller disassembled, showing addition of rings on disk faces

percent, rubber rings were placed over the faces of the disks, as shown in figure 3. Later a rubber bar across the face of the stationary disk was used instead of the rings, as shown in figure 4. The rings seemed to be better adapted for plot work, or where small quantities of dif-

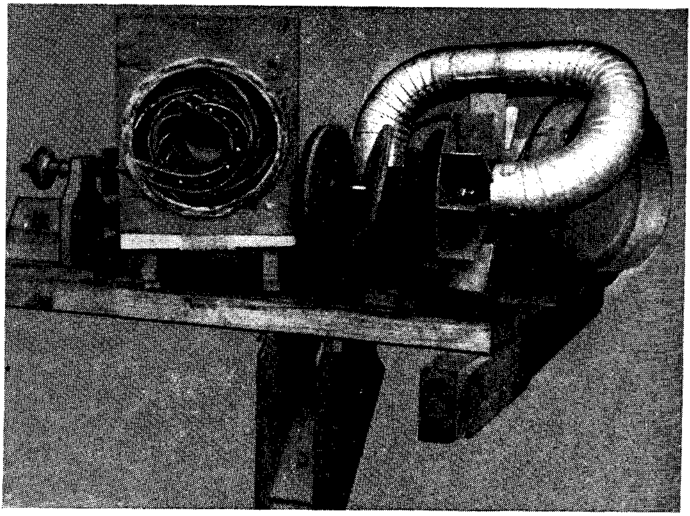

Fig. 4—Sheller with cleaner. Hopper removed to show the rubber bar used instead of the annular grooves.

ferent varieties of beans were to be shelled, including the large black beans with hard woody shells. When the bar is used instead of the rings, the machine is less critical in adjustment, and both seed injury and shelling percent are slightly decreased. The rubber used on the faces of the disks was 3/8-inch thick, black, soft, abrasive resistant sheet rubber, with a specific gravity of 1.15.

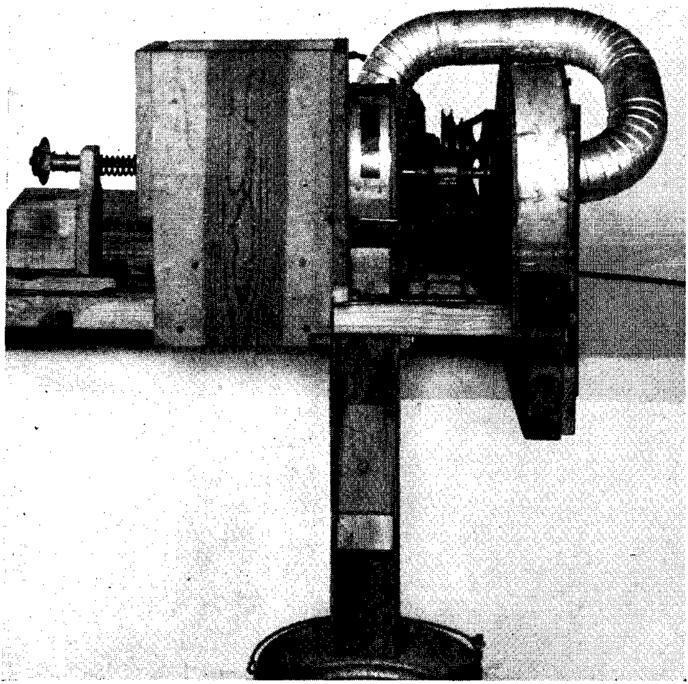

Fig. 5—Sheller assembly complete with suction-type cleaner

To protect the operator from dust, to combine the shelling and cleaning operations, and to aid in the adjustment of the machine, a cleaning duct connected to a suction fan was added, as shown in figures 4 and 5. An 8-fin fan, 12 inches in diameter and 2½ inches wide, was mounted near the end of the shaft opposite the disk. The seed and shells drop into one branch of a Y cleaning duct, 2 inches by 2½ inches in cross section, and mounted below the base. The other branch of the duct is connected to the suction, or inlet, side at the fan housing with 3-inch conductor pipe fittings. All dust and shells are drawn up the duct into the fan, while the beans drop down through the duct into a container in full view of the operator. With the exhaust of the fan connected to the outside of the room or shelter, dust and chaff are removed and drawn away from the operator, while the beans are shelled and cleaned in one operation. The cleaning action is very positive in removing trash and light-weight, immature, or unfilled beans, but it does not remove sound, unshelled, or injured seed. If some of the beans are cracked, the disks may be moved farther apart. If too many beans remain in the shell, the disks may be moved closer together.

RESULTS WITH THE DISK-TYPE SHELLER

Many factors, such as variety, maturity, moisture content of the bean, and adjustment of the machine, affect the shelling percentage. Some varieties in damp weather seem to be "in case" and difficult to shell, but if they are stored in a heated room they will shell readily. Others have a hard woody shell surrounding a large black bean that is injured easily. The beans used in the trials (table 1) were not tested for moisture or stored in a room with controlled humidity, except U. S. No. 4, which were thoroughly dried before shelling.

Table 1—Effects upon shelling and seed injury of certain construction details and adjustments of the new castor-bean sheller.

Test No.	Description of rubber disks used	Revolutions per minute	Shelled beans	Injured beans	Remaining in shell
			Percent	Percent	Percent
1	No grooves in rubber	1750	85.0	8.7	6.3
2	Radial grooves (1/8 inch)	1750	89.9	3.9	6.2
	Clearance changed	1750	92.6	5.6	1.8
3	Radial grooves (1/4 inch)	1750	89.6	1.1	9.3
	Clearance changed	1750	91.0	1.9	7.1
4	Spiral grooves	1750	91.1	3.3	5.6
	Clearance changed	1750	93.2	1.3	5.5
5	Spiral grooves	1250	94.6	1.1	4.3
	Clearance changed	1250	91.9	0.7	7.4
6	Rubber rings on face	1250	96.5	0.9	2.6
	Clearance changed	1250	96.4	2.7	0.9
7	Rubber rings on face	1000	95.7	4.2	0.1
	Clearance changed	1000	96.9	0.8	2.3
8	Rubber bar across face	1000	97.6	0.9	1.5
	Clearance changed	1000	94.7	0.4	4.9
9	Rubber bar and U. S. No. 4 beans	1000	99.69	0.01	0.3

The variety used in tests 1 to 8, inclusive, was reported as the Connor. Results are based on beans picked in the field after frost but not dried and cured before shelling. Only fully matured seed with firm shells were used in these tests. In test 9, on U. S. No. 4, the beans were dried before shelling.

Two adjustments are listed for each test. One was an attempt to secure minimum injury and fair shelling and the other was to secure maximum shelling without a much higher percent of injury.

A small experimental machine with 6-inch disks was constructed and tested. When small, well-cured beans were used, such as U. S. No. 4 in test No. 9 (table 1), practically all of them were shelled without injury. The capacity of the machine is about 1 bushel per hour, depending on its adjustment and the kind of beans. With small beans this rating was slightly exceeded.

The ¼-horsepower single-phase motor drew 563 watts from a 115-volt line when idle. The belt and machine idling increased the power requirement by 35 watts. Shelling U. S. No. 4 beans at about 1 bushel per hour increased the power requirement an additional 36 watts. In the shelling of plot beans, which included a large number of varieties of wide variation in type, no undue heating of the motor was noted.

The feeding of the beans into this small machine is semi-automatic. The seed clusters do not have to be broken up, but large ones, because the machine is small, must be forced in by hand. This machine seems to be especially well adapted for plot work. It is quickly adjusted, but not critical in adjustment. Many varieties of castor beans from the Experiment Station plots were shelled, with varying results.

Because of its simplicity and ease of adjustment, the shelling can be done on the farm to save shipping or handling costs and to facilitate grading or marketing. The machine can be constructed easily in any small shop, or even on the farm, with little expense, until more extensive cultivation of castor beans warrants commercial production.

Although the experimental machine as constructed is too small for commercial use, the practicability of larger machines of similar type is anticipated. The area of a disk varies as the square of the radius, and the capacities of machines with larger disks should increase in approximately the same proportion.

This machine also shells peanuts, especially the smaller varieties.

ACKNOWLEDGMENT

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FARM AND COMMERCIAL SHELLERS

Since this bulletin went to press, an improved sheller, with 12-inch disks and vacuum-type cleaner, has been built. It is similar in construction to the smaller machine. It is operated by a ½-horsepower motor, and has a capacity of about 6 bushels of shelled beans per hour. Above 99 percent of the beans fed into it will be hulled without injury when dried ready for shelling. This 12-inch machine is believed to be ample for individual farm use (see figure 6).

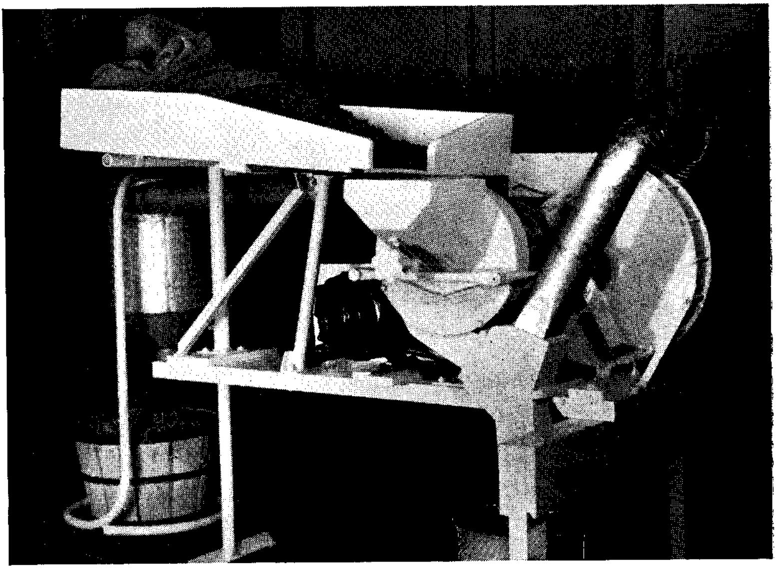

Fig. 6—A 12-inch sheller, believed to be ample for individual farm use.

A 24-inch machine, with an anticipated capacity sufficient for commercial use, is under construction.

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