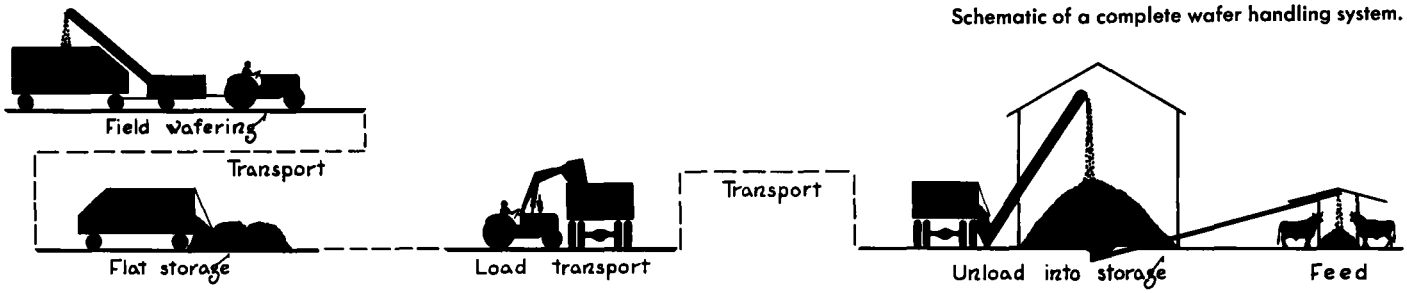

Schematic of a complete wafer handling system.

HAY WAFERING: *an analysis of current machinery for production, handling and feeding*

J. B. DOBIE

Continuing demands of stockmen and feed dealers for improved methods of handling hay have stimulated interest in hay pelleting and wafering machines. Handling problems in California are further complicated by the need to transport hay long distances from areas of production to consumption. Pelleting or wafering is intended to package hay in a dense, free-flowing form that can be handled, transported, and stored in bulk. Pelleted hay (made from ground hay) has the best density and handling characteristics, but lacks the coarse roughage considered necessary for dairy cows. Wafered hay (produced without grinding) contains sufficient roughage to overcome this objection.

In the last three years, several hay wafering machines have been tested in California. During 1961, some 6000 tons of hay were produced and fed in wafer form. Most major farm machinery manufacturers and some small machine shops in California have active research projects in this field; many of them have experimental machines in some stage of development.

Machines tested

Many machines have been tested to some degree, but in northern California, three types have received the most attention:

(1) A roller type, in which the windrow is compressed between two rollers, producing a ribbon of hay which is cut off in short pieces. The machine under trial produced wafers approximately 3 × 3 inches and one inch thick. Size is dependent on the width of the rollers and the cut-off device.

(2) A reciprocating plunger machine, in which the hay is fed in front of a ram which then pushes the material through a restricted opening or die. The size of the wafer depends on the dimensions of the die holes. The most common size produced locally has been 1½ inches square and ½ to 2 inches long.

(3) A combination roller and die machine, in which rollers are used to force the hay into the die holes. Again, size depends on die dimensions which, in existing models, are 2 × 2½ inches. Length of the wafer is controlled by the setting of break-off plates.

Most of the wafers have been produced in semi-experimental operations by commercial hay growers using the three types of machines mentioned above. About 90 per cent of the total output was the 1½ inch size, made with three plunger-type machines operated by Heidrick Bros. of Woodland, California. Most of the balance of the wafers were produced with Lundell roller-die machines.

In general, the smaller and the more nearly round or cubed, the better wafered hay can be handled in bulk. The 1½ inch cubes flow readily from bottom-dump transport trucks. In the larger sizes unloading is more difficult, particularly if the wafers are flat rather than cubed. Although smaller sizes of wafers are best for handling, in the interest of developing machine capacity, most designers prefer the larger sizes.

In addition to the size of the products, density and handling characteristics are important. Density varies with operating conditions but, for alfalfa, averages about as indicated below. By comparison, baled hay has a bulk density of 10 to 14 pounds per cu. ft.

WAFER CHARACTERISTICS

Type of machine	Average wafer size—in.	Bulk density lbs/cu ft	Flow
Roller	3 x 3 x 1	20–24	Poor
Plunger	1½ x 1½ x 1	24–30	Good
Roller-die	2 x 2½ x 2	18–24	Intermediate

Loading wafered hay into a transport truck with a 1 cu. yd. skip loader.

Moisture content

Moisture content of the wafers affects both the operation of the wafering machine and storage of the wafers. Generally, the roller machine works best from 12 to 18 per cent moisture content. A water spray is used to extend the working day after the effect of morning dew has disappeared. The die machines normally operate in dry hay at 6 to 12 per cent moisture content with water added during wafering. In the plunger machine, the moisture content of the hay may be increased by 6 or 7 per cent, depending on the moisture content of the hay in the windrow. The roller-and-die machine requires more water, often resulting in increasing the moisture content 15 per cent or more. In some cases, this machine has produced wafers of 21 or 22 per cent moisture content, which is too high for safe storage.

A self-feeding barn for cubed hay. Storage space is 12 feet wide and 15 feet high. Hay is fed in mangers along each side.

Handling and transport

The schematic view included with this article shows various operations involved in a normal wafer handling system. The wafers are elevated into a holding bin or wagon, then hauled to and dumped on a slab for temporary storage. From here, a skip loader (see photo) is used to load them into the transport truck, which hauls them to the consumer. At the ranch, the wafers are transferred into storage bins from which they are fed. There are at least four storage or holding points, including the wagon and transport truck. In this system, there are four elevating operations and 10 to 12 transfer points, providing many opportunities for damage resulting in fines or trash. However, there is a great labor saving potential compared to handling baled hay, where many of the elevating and transfer operations are done by hand labor.

The Heidrick machines, built by Cal-Cube, Inc., Woodland, use a bulk bin on the machines, which is hydraulically dumped into a dump truck for transport to the flat storage. Two trucks will normally service three machines, each producing 2½ to 3 tons per hour, unless the distance from field to flat storage is 10 or more miles. In the future, it may be possible to eliminate the flat storage for at least part of the hay by dumping directly into the transport unit in the field.

Unloading wafers from the transport into the consumer's storage barns can be a problem, particularly on uneven terrain. An elevator-conveyor system in the barn with an easily accessible delivery point for the transport is usually the best solution. With this method, a 25-ton truck-and-trailer load of 1½ inch cubes can be unloaded in an hour with virtually no hand labor. Unloading the same amount of larger wafers may take up to two hours and some manual persuasion to keep them flowing.

Wafer feeding

Most of the wafered hay is fed to dairy animals and concentrates are fed separately. Mechanical feeding by conveyor, or self-feeding from storage, have both been found successful.

Wafers that are to be fed mechanically may be kept in any weather-tight storage building strong enough to withstand the lateral pressure. A conveyor in the floor of the storage area can be used to carry the wafers to the feeder, where another conveyor distributes them to the animals. Some hand labor is involved in controlling the amount of wafers fed at each operation of the feeder. However, controlled feeding is a necessity to minimize waste. Mechanical feeding tends to mix the wafers so that there is little tendency for cattle to eat one lot and reject another.

The good flow characteristics of the 1½ inch cubes allow successful use in self-feeding barns (see photo). These barns are built like regular self-feeders for grain but have a larger capacity. Self-feeding barns are from 12 to 18 feet wide with storage space 15 to 20 feet deep, and as long as necessary to provide adequate storage and feeding space. A barn-filling conveyor runs the length of the barn, just under the peak of the roof. For feeding, the wafers flow out into feed bunks along each side. The rate of flow should be controlled to limit the amount that is fed each day. If wafers are allowed to flow freely, the cattle will eat the wafers and refuse the fines, resulting in excessive waste. Cows may also prefer certain lots of hay, causing uneven unloading of the barn.

Feeding methods for larger wafers have not been well established, due to the limited quantity that has been available. In general, cattle seem to eat all sizes and shapes satisfactorily, except that hard wafers in the larger sizes are the last to be consumed. Dairymen report some increase in hay consumption and milk production where 1½ inch cubes have been fed in place of baled hay. Controlled feeding trials have shown similar results. One beef feeder reports excellent results where wafers and concentrates are mixed as distributed to the feed bunk.

Machines using the plunger and the roller-die principles will be available in limited quantity in 1962. Additional experience with these machines and with improved handling systems should provide much-needed information on the economics of wafered vs. baled hay.

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