COMPLETE RATION CUBING

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Cubing of complete rations will never be an exact science because of the wide range of operating conditions and formulations with which the operator must work. Therefore, I will not attempt to tell you just how the job should be done. Rather, I will try to give you an idea of some of the factors that have to be considered in making a good cube, regardless of conditions.

First, let us consider what is a good cube. The American Society of Agricultural Engineers has set up standard methods for determining density and durability as measures of physical quality of cubes. We measure and weigh a cube to determine its individual density. However, as producers or users, you are most interested in bulk density of a quantity of cubes. Generally speaking, I consider cubes with 25 to 30 lb per cu ft bulk density to be good; anything above 30 lb is very good, and below 25 is poor. However, these values should be considered in conjunction with a durability rating if we are to have any real knowledge of how the cubes will handle. This is more important with complete ration cubes than for hay cubes.

The ASAE standard method for determining durability is to tumble 10 cubes in a rectangular box for 3 minutes, and then determine the extent of breakage (see Appendix I). Two ratings can be obtained from this: 1) a 0 to 100 rating which indicates the percent of the remaining pieces of cubes that are larger than 20 percent by weight of the average of the original cubes, and 2) a durability index on an expanded scale of 0 to 400 which indicates the extent to which the cubes break into smaller pieces. I believe durability is more important than density in determining the quality of complete ration cubes, as large amounts of grain and other heavy feedstuffs tend to increase density without necessarily improving durability. Thus, you could have a heavy cube that would not handle well. From my experience, the following durability classifications are a reasonable indication of the handling characteristics of cubes.

	Durability Rating 0 to 100	Durability Index 0 to 400
Very good	90 to 100	350 to 400
Good	80 to 90	300 to 350
Fair	70 to 80	250 to 300
Poor	60 to 70	200 to 250
Unsatisfactory	below 60	below 200

Equipment for Complete Ration Cubing - Complete ration cubing can best be done in a stationary cubing operation. It is obvious that the amount of feed supplements that can be added to forage in the field cuber is very limited. Stationary cuber installations usually include a continuous mixer for distributing water on the hay. This same unit is capable of mixing grain and concentrates in a satisfactory manner. The principal problem is obtaining suitable accuracy in proportioning hay and grain by the volumetric methods usually used with a continuous-mix system. The alternatives are to use weigh belts to measure the feed rates of the various ingredients, or to use a batch-mixing system, with a surge bin to provide continuous flow of mixed ration to the cuber.

Storage of grain and concentrates will be a function of the types of different ingredients and their amounts required in producing the complete ration. For a minimum-scale operation, it might be most economical to use a pre-mixed grain and concentrate feed, thus requiring only one storage unit and one conveyor to deliver the feed to the mixer. For larger operations, or those geared to varying the total ration for different uses, it would be preferable to have separate storage for each ingredient, with suitable controlled-rate metering devices to deliver selected ingredients to a central mixing point.

Cube cooling and storage requirements are about the same for complete ration cubes as for hay cubes. However, if complete ration cubes are to be produced during the winter, greater protection must be provided in areas of appreciable rainfall. Forced air cooling of cubes will facilitate handling, and should be considered for stationary cubing installations.

How to Produce Complete Ration Cubes - Many factors affect cube quality and also nutritional value. Some of the more important things to consider are:

1) Maintaining maximum fiber length in the forage portion of the ration. This is particularly important as the proportion of forage is reduced in a ration for high producing dairy cows as a means of maintaining butterfat production. We have found that an average length of chop of 1 1/2 to 2 inches helps to produce a more durable cube, and satisfies the roughage requirement.

2) Ground grain makes a better cube than does rolled grain. Most grains are high in carbohydrates, and these help as a binder when water is added. Grinding increases the total surface area of the grain particles so that the binding effect is improved.

3) Elimination or reduction of fat in the ration. Fat is a lubricant which reduces cohesion between feed particles. Where possible, replace fat in the ration with molasses or some other ingredient.

4) Include in the ration feed ingredients that serve as natural binders. Some feedstuffs, such as dried beet pulp and ground almond hulls, are good binders.

5) The proportion of hay to grain and concentrate for making a good cube varies with the ingredients in the grain portion of the mix. In general, a good cube can be made with 70 percent or more hay, provided the other factors mentioned above are favorable. For some rations, good cubes can be made with as little as 60 percent alfalfa.

6) Addition of a commercial binder if necessary. There are numerous commercial bonding agents that can be used to improve cube quality. These include both dry and liquid materials, with a wide range in cost and nutritional value. In experiments at the University of California at Davis, we have produced good to very good cubes with only 40 percent alfalfa in the ration, by using 3 percent of a pre-jelatinized corn and soya flour binder. Without a binder, this ration would not make a satisfactory cube.

Moisture can be a problem, particularly with dry binders which require water for activation. During the summer, average moisture content of all ration ingredients may be about 10 percent, permitting the addition of enough water to increase cube moisture to about 15 percent, which is usually adequate for activating the binder. The same feed ingredients may average 13 or more percent moisture during the winter. Thus, when sufficient water is added to make a good cube, the cube moisture may be 17 or 18 percent. Such high-moisture cubes require drying or special handling to control spoilage.

Production Cost - Cost of complete ration cubes depends primarily on cost of the ingredients. Cubing cost will not vary appreciably from that of a normal stationary cubing operation with hay, as increased capacity will about offset the extra equipment needed for storing and handling the additional ingredients. Cuber capacity of up to 10 tons per hour is possible, depending on the ration.

Feeding Trials - A feeding trial in progress more than 1 1/2 years at Davis is due for completion in March, 1973. Three rations are being tested: 1) 40 percent alfalfa, 60 percent grain and concentrate; 2) 50 percent alfalfa, 50 percent grain; and 3) 60 percent alfalfa, 40 percent grain. Approximately 100 tons of each of these feeds have been cubed since January, 1971. The physical characteristics of the cubes have varied with initial moisture content of the hay and grain, but in spite of this, bulk density of the cubes has been fairly consistent between 30 and 35 lb per cu ft. A pre-jelatinized starch has been premixed with the grain portion of the ration, averaging 3 percent of the total ration by weight. A water spray was applied in a continuous paddle-type mixer to activate the binder and also the starch in the ground barley. Durability rating has averaged about 92 percent for the 60 and 50 percent grain rations, and 96 percent for the 40 percent grain ration. Durability index has been approximately 360 for the same high grain rations, but 380 for the 40 percent grain ration. Moisture content of the cubes has been higher than desired, usually 17 to 18 percent as they emerge from the dies.

Production data are not available at this time; however, animal performance appears to be good. More cubed than milled rations are being consumed, and no health problems are evident with the complete ration cubes.

Appendix I

to

Complete Ration Cubing

Excerpt from ASAE Standard, ASAE S269.1
Wafers, Pellets, and Crumbles (reconfirmed, 1970)

Printed by permission of American Society of Agricultural Engineers, St. Joseph, Michigan from the Agricultural Engineering Yearbook, 1972, page 336.

SECTION 6 - DURABILITY

6.1 Wafers The durability of wafers shall be determined by the following procedure:

6.1.1 Device. Durability of wafers shall be determined by tumbling the test sample for 3 minutes at 13 rpm. The outside dimensions of the angle iron frame of the tumbler are shown in Fig. 1. The covering shall be 0.5-in. mesh hardware cloth applied taut to the outside of the frame. Interior projections, such as screw heads, should be kept to a minimum and should be well rounded. The box shall be mounted on a diagonal axis (two planes) with two stub shafts terminating at the exterior of the angle iron frame. These may be hollow shafts for ease of fabrication. There will be hinged triangular door 12 by 12 by 17 in. on each end. The axis of rotation shall be horizontal (Fig. 1).

6.1.2 Determining durability of wafers. Wafers shall be tested by tumbling a representative 10-wafer sample, whose individual weight does not vary over ± 10 percent of the average original weight, in the manner described in paragraph 6.1.1.

6.1.3 After this tumbling test, the total weight of all particles each weighing more than 20 percent of the average initial wafer weight shall be recorded and designated as wafer size material (WSM). The durability rating for wafers is expressed as the percentage of WSM.

6.1.4 Using the original average wafer weight, compute five weight classes, each expressing 20-percent increments of the original average wafer weight. Separate the wafer pieces remaining after tumbling into piles prescribed by the five weight classes Pieces weighing more than the average original wafer weight will be included in the highest weight class. The percentage of material in each class shall then be determined by dividing the total weight in each class by the total weight before testing.

6.1.5 A size-distribution index of the durability is then obtained by multiplying the percentage of material in each of the five classes from highest to lowest respectively by four (4), three (3), two (2), one (1), zero (0), and then calculating the summation of products obtained by this method: A perfect index is 400.

6.1.6 EXAMPLE AND SUGGESTED WORK SHEET

Sample Number	Weight Classes of Wafers* % original weight in each class					Size-Distribution Index	Durability Rating
	50-40g	40-30g	30-20g	20-10g	10-0g		
1	92	---	---	---	8	368	92
2	40	48	---	---	12	304	88
	8	47	15	10	20	213	80
	---	40	20	18	22	178	78

*Example assumes original average weight per wafer is 50 grams.
NOTE: Wafers formed by extrusion may hang together in clusters of two or three. These wafers should be separated at their cleavage planes into reasonable lengths. Each resulting unit should be treated as an individual wafer.

6.1.7 The time interval between forming and durability testing should be specified. The moisture content of all the pieces, as a group sample taken immediately after the durability test, should also be specified.