The Fatted Calf: More Weight Gain with Less Feed

Beef may well be the favorite food of Americans. But the rising cost of grain, used in fattening half to two-thirds of all beef consumed in this country, has made it financially difficult for many Americans to consume as much beef as they would desire. Cattlemen have attempted to keep the price of beef down by adopting technological innovations, such as implants of the hormone mimic diethylstilbestrol (DES), to improve the efficiency with which cattle convert their feed to added poundage. But DES is generally considered to be a carcinogen, and recent evidence indicates that traces of DES remain as metabolites in the livers of cattle that have been given this drug. The use of DES for fattening cattle has already been banned in many foreign countries, including Canada, Japan, the United Kingdom, Australia, and West Germany, and it seems only a matter of time until its use is also banned in the United States.

To replace DES, cattlemen are seeking other methods to improve the efficiency with which cattle gain weight. Three U.S. companies have recently begun promoting products that they claim will provide the desired effect. Each of the products is quite different: One is a feed additive that improves the efficiency of fermentation in the rumen, one is a feed additive consisting of microencapsulated lipids, and one is a plastic vaginal insert. Each works by what appears to be a rather unusual mechanism, but that they do work has been documented by a number of independent investigators. The three methods together promise to keep the cost of beef from rising dramatically in the near future. They also provide interesting illustrations of the types of technological innovation that may be necessary to allow the world to feed its growing population.

The primary use of the new products will be for fattening cattle in feedlots, enclosures where the cattle do little more than eat and gain weight. In a typical example, a 320-kilogram steer (a castrated male) or heifer (a young female that has never calved) might be kept in a feedlot for about 150 days, during which time its weight would increase to about 480 kilograms. Without stimulants, this weight gain would require about 1500 kilograms of grain (about 9.5 kilograms of grain per kilogram of weight gain) at a cost of about $165, figuring grain at $110 per metric ton. Implants of DES improve the efficiency of feed conversion about 10 percent on the average; a 160-kilogram gain would thus require only about 1350 kilograms of grain. The net result is that about 30 cents worth of DES (two implants) lowers the feed cost of the feedlot operator by about $16.50.

Other hormones, such as estradiol, testosterone, and melengestrol acetate, are also used to improve weight gain. Most of these are hormones that occur naturally in cattle, so there is less concern about their possible side effects. In a few foreign countries, however, these hormones are forbidden because the beef cattle are also a source of milk. The hormones are generally less effective than DES, and there are also other problems. Some hormones, for example, may occasionally cause darkening of the meat; others can only be used at least 60 days before the time of slaughter. Feedlot operators are thus searching for effective products that are more acceptable and present fewer potential problems.

Perhaps the most effective of the new products is Rumensin, developed by Elanco Products Company, a division of Eli Lilly and Company of Indianapolis. Rumensin is the trade name for monensin, a fermentation product from *Streptomyces cinnamonensis*. It is thus formally classed as an antibiotic, but it actually has only a very limited antibiotic activity. It works by altering the metabolic products of microbes in the rumens of cattle.

Microbes Predigest Feed

These microbes convert the ruminant's feed—whether grass, hay, silage, or grain—into a form that is more efficiently digested. Plant fibers and starches are first broken down into sugars. These sugars are then converted into certain volatile fatty acids—acetic, butyric, and propionic—which are the ruminant's principal source of energy. In a typical feedlot situation, according to Roger Muller of Elanco, rumen microbes convert sugars to about 60 percent acetic acid, 10 percent butyric acid, and 30 percent propionic acid.

But the production of acetic and butyric acids wastes food energy. Conversion of a six-carbon sugar to acetic acid (a two-carbon acid), for example, yields two moles of acid per mole of sugar and a total of two moles of carbon dioxide and methane, which are waste products. Similarly, one mole of sugar yields one mole of butyric acid (a four-carbon acid) and two moles of waste products. But one mole of sugar yields two moles of propionic acid (a three-carbon acid) and no waste products. Lilly scientists thus screened large numbers of chemicals, looking for those that would alter the proportions of volatile fatty acids. With monensin, their final choice, the proportion of acetic and butyric acids declines to 60 percent, while the proportion of propionic acid rises to 40 percent. Consequently, the animal wastes less of the energy in the feed it consumes.

Feedlot cattle will normally eat only enough to satisfy their energy needs, Muller says, so monensin does not increase their average daily weight gain. But since they get more energy per unit of feed, it does decrease their consumption by a little more than 10 percent, or by about 1 kilogram of feed for every kilogram of weight gained. Thus, about $2.22 worth of monensin would reduce the cost of feed for a 160-kilogram gain by about $17.50, a saving of 10 cents per kilogram. The effects of monensin and hormones or hormone mimics, furthermore, are additive. Under optimum conditions, according to university scientists who have conducted trials, a combination of monensin and DES can reduce total feed requirement by as much as 25 percent.

Lilly scientists have tested monensin in more than 5000 head of cattle to establish its efficacy and safety. They are not certain of the exact mechanism by which monensin increases the proportion of propionic acid. But withdrawal of monensin restores the normal balance of fatty acids in a few days, an indication that the antibiotic does not permanently alter the proportions of microbial species. The product leaves no residues or metabolites in the meat obtained from animals that have consumed it. Monensin and its metabolites degrade rapidly when they are released to the soil in manure, and they do not affect the growth of crops fertilized with the manure. And finally, the additive does not affect the quality of beef carcasses, their composition, or the ease with which they can be cut. The Food and Drug Administration (FDA) gave approval for use of Rumensin at the end of 1975, and it is now on the market.

The second product is a feed additive consisting of microencapsulated animal fats. The product was developed by Alta Lipids Inc. of Boise, Idaho, using technology introduced by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Canberra, Australia. Alta Lipids hopes to obtain FDA approval for their product this year.

The animal fats are glycerol esters of long-chain fatty acids. Like the shorter volatile fatty acids, these are high-energy compounds that can be used directly in the cattle's metabolism. But the rumen, according to Kenneth Lyon of Alta Lipids, can tolerate no more than about 6 percent total fat in the diet without a depression in feed intake and weight gain. By encapsulating the lipids in a protein, the CSIRO scientists have made it possible for the encapsulated products to reach the gastroin-

testinal tract without disturbing the rumen.

The encapsulating protein is derived from oil seeds. It is solubilized with a dilute solution of sodium hydroxide, then combined with an inexpensive animal fat, such as beef tallow, to produce a creamy emulsion. The emulsion is treated with formalin (a solution of formaldehyde) to produce a gel of protein-coated fat droplets that are 1 to 5 micrometers in diameter. The gel is dried to yield a coarse, free-flowing meal that can be combined with other feed. This meal is about 40 percent lipid and sells for about $375 per metric ton.

The encapsulating protein is inert in the rumen, allowing the additive to pass into the animal's digestive tract. There, various enzymes and acids break down the protein coat, allowing the fats to be absorbed and used by the ruminant. Radioactive tracer studies, Lyon says, indicate that all the formaldehyde is excreted.

The efficacy of the additive depends on the feeding situation, according to Lyon. If the cattle are fed a high-quality, low-roughage feed such as corn, the additive has little effect on the average daily weight gain or efficiency of feed conversion. It does, however, improve the fat-to-lean ratio, so that a significantly greater proportion of the carcass can be graded "choice." This, in itself, can be financially profitable, since choice grades carry a premium of as much as 26 cents per kilogram compared to meat graded "good."

The microencapsulated lipids improve weight gain and conversion efficiency mainly when the total caloric intake of the animal is limited by the volume of its four stomachs. This can be the case when high-roughage feeds such as silage and hay are used, or when the animal is allowed to graze on the range. In these cases, the additive can produce as much as a 15 percent increase in efficiency of feed conversion and average daily weight gain.

Perhaps the most important use of the lipid additive, however, might be in the feed of dairy cattle. A typical dairy cow, Lyon says, may consume about 22 kilograms of food per day to produce an equal weight of milk. Controlled trials in England and Canada, he says, indicate that replacing as much as 3.25 kilograms of the cow's daily feed with the lipid additive increases milk production by an average of about 11 percent. Furthermore, all the milk produced then contains about 17.5 percent more butterfat.

CSIRO has developed a similar product, not yet cleared for marketing in the United States, that incorporates polyunsaturated fats from safflower, sunflower, or soybean oil instead of beef tallow. When this product is fed to cattle at about 30 percent of the diet, the proportion of unsaturated fats in the beef increases from the normal 4 percent to as much as 25 percent. (In cattle, most polyunsaturated fats in the diet are hydrogenated by microbes in the rumen.) Beef containing more polyunsaturated fats might be desirable for heart patients and others who must restrict their intake of saturated fats. The price of such meat—about 80 percent higher than regular beef in Australia, where it is now marketed—might limit its use, but Lyon thinks the price differential will be smaller in this country. When the polyunsaturated additive is fed to dairy cattle, the proportion of unsaturated fats in the milk can be increased from the normal 3 percent to as high as 30 percent. Alta hopes to be able to market the polyunsaturated additive in the United States within a year.

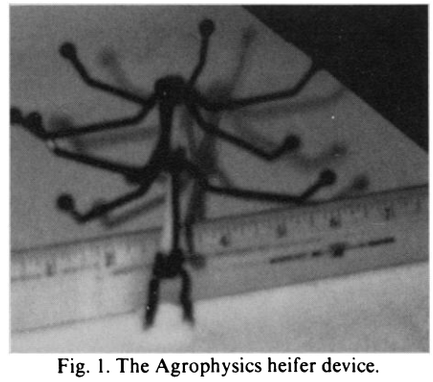

Fig. 1. The Agrophysics heifer device.

The most intriguing of the new products is the intravaginal heifer device developed by Agrophysics Inc. of San Francisco. It is a pencil-thin rod (Fig. 1), about 9 centimeters long, composed of biologically inert nylon; from one end of the rod protrude 12 knobbed nylon branches about 6 centimeters long. The entire device is inserted in the vagina of a heifer, where the knobs contact the vaginal wall to anchor it in place. Insertion of the device, according to Wade Dickinson of Agrophysics, increases both the average daily weight gain and the feed conversion efficiency. Preliminary evidence also suggests that it prevents the heifer from conceiving.

The device was discovered accidentally. Dickinson and his brother Wayne were attempting to develop a mechanical device to indicate when cows are in estrus as an aid to mating and artificial insemination. The estrus indicator is not yet a commercial product, but the brothers observed that emplacement of the indicator in the vagina stimulated the expression of estrus. They therefore undertook studies of the device with the cooperation of George Crenshaw, a consulting veterinarian in Davis, California, and George Stabenfeld of the University of California at Davis.

It was soon discovered that similar devices have a similar stimulatory effect in pigs and a contraceptive effect in dogs. Agrophysics has, in fact, been marketing a canine contraceptive device—called Option One—for almost a year. More important, Dickinson says, they observed the effect of the device on the weight gain of heifers, which generally are not as efficient as steers in converting feed into meat.

In a series of controlled feedlot trials supervised by Crenshaw, Agrophysics has found that the device produces a 4 to 5 percent increase in the average daily weight gain and a 4 to 6 percent increase in the efficiency of feed conversion. Even larger effects were observed in cattle that grazed on rangeland. The effect of the device is most pronounced with older and larger (more sexually mature) heifers, resulting in larger increases in weight gain near the end of the feeding cycle.

With the use of the device in a feedlot situation, Dickinson says, the net decrease in production cost varies from about $8.50 to $13, depending upon the type of feed used. The device costs about $1.50 to $1.75 and can be inserted by unskilled personnel in about 40 seconds—generally at the same time the animals are given their inoculations. The device remains in place until the animal is slaughtered unless the animal is to be used for breeding, in which case the device can be readily removed. It can also be used after conception. The effects of the device are additive to those of hormones and DES, Dickinson says, but it has not been tested in conjunction with Rumensin.

How the device works is a mystery comparable to that associated with the fattening effects of hormones and the contraceptive effects of intrauterine devices. The heifer device does not occlude the vagina to prevent sperm from passing through and it does not prevent mating. Neither does it interfere with the heifer's estrus cycle. Dickinson speculates that the device might act as a neural stimulator through some pathway connecting the hypothalamus and the vagina. In this fashion, it could affect the production of various hormones involved in the growth and reproductive processes.

The use of such products is obviously profitable for cattlemen and feedlot operators, but the argument can be made that it is also profitable for the country as a whole. If Americans must continue to eat beef, the products will not only lower the cost of beef to the consumer, but will also help to conserve food resources. If the efficiency of feed conversion of all feedlot cattle in the United States could be improved by only 10 percent, according to Thomas H. Lake of Lilly, more than 4 million metric tons of grain would be available in 1976 for other uses. Conceivably, some of this grain could be used to feed people who can't afford to purchase beef.—THOMAS H. MAUGH II