Many antibiotics, such as aureomycin, terramycin, penicillin, streptomycin, oleandomycin, tylosin, zinc bacitracin, and certain combinations of these antibiotics, have consistently increased gain and improved feed efficiency and health of pigs.

It is difficult to arrive at a single set of figures that will truly assess the contribution of antibiotics, arsenicals, and other bactericidal agents to the swine industry. The stimulation from antibiotics and arsenicals varies with the age of the pig and the disease level. Fourteen experiments conducted at the Ohio Experiment Station from 1957 to 1961 have shown that feeding aureomycin from weaning to 120 pounds improved gain 8.6% and feed efficiency 9.6% and from 120 pounds to market 3.4 and 7.1%, respectively. An over-all average showed a 6% increase in gain and an 8.4% improvement in feed conversion. Many times the response from antibiotics is not so great under carefully controlled conditions and selected pigs in an experiment station herd as on the average swine farm.

Poor-doing pigs ("tail-end") respond more favorably to antibiotics than healthy, thrifty pigs. Research at Purdue has clearly shown fortifying a pig ration with 100 grams of either aureomycin or terramycin per ton will increase the growth rate of "tail-end" pigs 0.53 pound daily or an increase of 49%. Also, field studies have indicated that early weaned pigs (3 weeks) respond markedly to antibiotic feeding with an increase in gain of 42% on 11% less feed.

Similar responses have been obtained in young pigs and growing-finishing pigs by feeding 90 grams of arsanilic acid per ton of feed or a combination of arsanilic acid with an antibiotic.

In four trials at the Missouri Experiment Station, sows fed 500 mg. of a tetracycline antibiotic per head daily for 10 to 21 days at breeding time farrowed 19% larger litters than sows not fed antibiotics. In two recent tests, there was no increase in the number of pigs farrowed, but all the sows fed antibiotics settled on the first service.

Research by Kentucky and Southern Illinois University has revealed that furazolidone (NF-180), when fed to the brood sow and young pigs, reduced death losses and increased weaning weight 3 to 6 pounds. Antibiotics have also been shown to be effective against certain types of pig scours.

Enzymes, tranquilizers, and hormone-like substances have not shown any consistent beneficial response as a feed additive for swine.

Guide for the Future

The use of feed additives and the fortification of livestock rations with essential chemical nutrients must continue on a safe and tolerance base (not zero) if we expect to improve feed conversion and feed the increasing population. Animal and human life are basically and essentially series of biological and chemical reactions fed by chemical substances. Man voluntarily or involuntarily consumes, breathes, and uses more potentially toxic products than will ever exist or be allowed in human foods. There are no more wholesome and nutritious products produced than milk, meat, and eggs. Through careful screening and research, we can keep animal products free from harmful substances. We need to control the use of feed additives not with a zero concept but with a tolerance and safe level concept.

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FEED ADDITIVES

The Significance for the Processor of Feed Additive Residues in Food

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ANIMAL feeds are customarily supplemented with nutrients and other additives to improve the quality and yield of foods of animal origin. This practice results in the production of more and better and cheaper foods; but these desirable consequences are somewhat offset by widespread concern over the possible existence in the food of residues of the feed additives.

Disagreements over the significance of residues, which may or may not exist, have been responsible for controversies growing out of legislation relating to this problem. There has been no disagreement with the objectives of the legislation, i.e., with protection of the food supplies.

Engel (*7*) has indicated that additives have an important place in present-day feeding practices and that these practices have significant influences on the quantity, quality, and cost of animal foods. As we deal with it here, wholesomeness is a defined characteristic, rather than an inherent property. Whether or not a substance or a food containing a substance is safe for human consumption depends upon the quantities consumed, the conditions under which it is consumed, the frequency of consumption, and many other factors. While safety is the principal criterion in considering additives, failure to use appropriate additives will result in fewer, lower quality, and more expensive foods.

The immediate topic of this paper relates to the significance for the processor of feed residues in foods. For this purpose, processing shall be defined as a conversion of the products of ranches or farms into forms suitable for purchase by the ultimate consumer. This excludes breeding, feeding, and shipping of the animal to the point of processing and retailing of finished foods. For the most part, these operations are beyond control of the food processor. Furthermore, this discussion will be directed toward products of animal origin, essentially meat, poultry products, and milk.

Food processors are in an unenviable position with respect to this problem. They do not benefit in any direct way from the improved yields brought about by feed additives, nor are they able to discern in many cases whether or not additives have been used. On the other hand, they are held accountable for the appearance of even the least detectable amounts of certain of these additives should they occur as residues in their products. In fact, they are held responsible for amounts presently undetectable, should improved methods be developed. Fortunately, realistic enforcement of clauses relating to "no-residue" provisions of food protection regulations would be expected to allow ample time to adapt feeding and operating practices to take improved methodology into account.

To scientists, considerations of residues of feed additives imply ability to detect and measure the residues with a satisfactory degree of accuracy. With many additives this is a major problem, particularly when there is insistence that no traces of residue remain. Chemists who have had experience with determinations of trace ingredients in foods or feeds are well aware of the complexity of the techniques needed. The procedures sometimes require several days for completion, even on a routine basis, and the determinations are prohibitively costly.

Additives are usually administered at concentrations measured in p.p.m. in the feed. Unless there is accumulation or localization of these residues in specific tissues, concentrations within the animal

Food processors acquire raw materials from all types of producers in many sections of the country; hence, the presence of residues of feed additives may be unsuspected, and even if detected, their origin may be unknown. Nevertheless, food processors must accept their share of responsibility for detecting and detaining foods that contain unsafe residues. If the criteria of safety are too critical, farmers and ranchers will be denied the use of valuable production aids, and processors and public health agencies will be saddled with the cost and nuisance of unnecessary testing. These influences will increase costs to the consumers, and the inevitable publicity attendant upon enforcement actions may further undermine public confidence in food supplies. In addition, the effort and expense involved in demonstrating complete safety of proposed additives under all conditions of use may be so great that development of more effective (and possibly safer) materials may be retarded.

products are extremely low, and the problem of separating, identifying, and measuring the amounts present is a very formidable task. Such a task, of course, is the delight of a true research chemist, but it is an impossibility for routine application.

Since analytical measurements of residues in finished products are so costly in time and produce, it might seem feasible for processors to maintain liaison with their suppliers and to determine whether or not additives had been included in animal feeds. While this is theoretically possible, it is not practical. Animals are shipped from widely separated areas to stockyards that serve as pools supplying several local meat processors.

In many stockyards, animals which have been purchased are pooled and then sorted into groups of uniform size and grade, irrespective of origin. Some of these livestock are then shipped to distant points for further feeding or processing. The sale and shipping of uniform groups of animals is a desirable practice insofar as marketing is concerned, but it shuffles animals from diverse origins into a single lot and makes even more difficult any tracing of origin or of initial feeding practices.

Theoretically, each animal could be accompanied by a certificate that would change hands much like the title of an automobile, so that its point of origin and type of feeding could be determined by the processor. Under these circumstances, the processor might then know whether to look for residues in this animal's tissues. The impracticality of such a certification seems obvious.

Random sampling of product, either by the industry or by enforcement agencies, can indicate only the general levels of residues in foods of animal origin. Such procedures can scarcely be considered adequate protection if harmful levels of residues are found. Prevention of accumulations of harmful quantities of residues, rather than detection of them, is the only solution to this problem; and prevention by control at the feedmill and feedlot level is the practice required by Food and Drug and Feed Regulatory officials. In fact, some of the producing industries insist that the regulatory agencies view control of new chemicals as a very simple process—simply ban them! But we know this is neither their position nor an answer to the problems additives raise. Effective control programs have been worked out for some feed additives; realistic approaches to new ones can result in equally satisfactory procedures.

One of the determinants involved in approval of a proposed feed additive is the residual amount of the additive or of its derivatives in edible tissues of animals to which it has been administered. Consideration of these residues is appropriate, but it raises several very interesting questions. Not the least of these concerns the level of residue that may reasonably be allowed to remain in meat, milk, or eggs. In certain cases, this amount is legally defined as zero, and the substances to which the zero limitation applies must be determined by administrative decision. It is here that there is room for differences of opinion, and there have been plenty of them.

Animals constitute very effective "biological filters" which tend to collect nutrients and to eliminate or detoxify harmful substances. Thus, high levels of a chemical in a feed, even when fed constantly, seldom result in comparable levels in tissue.

Furthermore, since feed additives are used in carefully controlled amounts to promote improved growth or better milk or egg production, only those substances that "benefit" the animal are used. Such beneficial effects are indications of safety, although the short-term (several months) administrations involved in farm and feedlot production do not give complete assurance that long-term consumption would be advisable. Since adverse animal responses are avoided, it is apparent that the additives, as used, are not harmful to the animal.

On the other hand, these additives may be more active for humans than for animals or they may accumulate in physiologically effective quantities in specific tissues. Until the question of safety can be completely resolved, the presence of detectable amounts of additives or additive residues in the food is cause for concern. Investigation of the residues does not imply harmful or undesirable properties of these residues, particularly since their appearance in tissues is the result of some beneficial action at the feedlot level. It should not be allowed to become so unnecessarily exacting that it constitutes a block to the development of more effective, and perhaps safer, additives.

One aspect of the residues problem is often overlooked—the increased public uncertainty regarding the safety of foods. Implications that new regulations are needed to prevent the "poisoning" of our foods inevitably raise doubts regarding the safety of foods. Thus, the forces that are insisting on vigorous protection of our food supply are, by the very sensationalism of their campaign, often tending to make food faddists of the public. Our health officials assure us that we have the safest, best, most bountiful food supply in the world.

Our abundant food supply is produced, processed, preserved, and marketed with the aid of approved chemicals. In many cases, the substances added only supplement or enhance the action of natural chemicals already in the food. The extent to which chemicals are essential in the production of our present wholesome foods is not generally recognized, and their present safe usage does not keep the public from viewing new uses of chemicals in foods with alarm. This is particularly true when residues or the possible residues are "libeled" by overzealous competitors or by those pressing for more exacting control measures. Discussions of food additives or other chemicals should be conducted on a scientific basis rather than politically or emotionally.

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