Diets in transition: human health and animal production. Consequences for agriculture and some possible new approaches

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There is a feeling abroad that the diet–health debate represents another nail in the coffin of animal production in the Western world. I do not support this notion. Undoubtedly the pattern of agricultural production is changing, but it always has in response to changing markets, lifestyles and incomes. The diet–health issue is certainly one component effecting change today but it must be considered in the light of longer-term trends reflecting the overall requirements and preferences of consumers and the socioeconomic policies of governments. For example, lamb may be frowned on nowadays by consumers as being too fat for their taste, but it is questionable whether sheep would be reared at all if it were not for the price-support mechanism for sheepmeat provided by the European Economic Community's (EEC) Common Agricultural Policy. We all might like to eat beef, but price will induce us to buy more chicken.

The agricultural and food industries, like all others, must be sensitive to market and other pressures. They must be able to monitor and interpret such pressures and devise ways of responding to them. The present paper reviews the background considerations and identifies some opportunities and means to respond.

Animal production and the diet–health debate

The production of meat worldwide is an enormous endeavour (Table 1) split approximately 2:1 between the developed and developing countries. In the UK it comprises about £3 billion or 30% of the total annual national value of agricultural activity. Much of the contributing sectors' activities overlap and interact in such a way that beef production is highly dependent on the national dairy herd and the supply of home-produced cereals may critically influence activity in the pig and poultry sectors.

World meat production is expected to have risen a further 16% during this decade, although the share of the market will increase for pig and poultry meat at the expense of beef and veal, mutton and lamb. The trends in total meat production in the UK over the last 20 or so years have been smaller but the contributions of the different species have changed in a similar manner (Meat and Livestock Commission, 1982).

Meat provides between 6 and 33% of dietary energy for the world's population and between 15 and 59% of protein, the lower values pertaining to developing and the higher values to developed countries (Food and Agriculture Organization, 1977). As communities become more affluent their consumption of meat increases and it is frequently extrapolations from these figures together with information on national morbidity and mortality which leads to the conclusion that the consumption of Western diets is a predisposing factor in heart disease and cancer. This simplification does not, however, even take into account the age structure of the populations nor the aetiology of the diseases concerned (Olson, 1981).

More recently the purported role of dietary fat in ischaemic heart and degenerative disease has received particular attention and dietary 'goals' of varying specificity have been devised by expert committees to accommodate this (Harper, 1981). The basis for such recommendations is frequently a combination of epidemiological analysis and the results of animal experimentation, both of which being matters for intense debate

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Table 1. *Production of meat ($\times 10^6$ tons) (From Food and Agriculture Organization, 1980)*

	World	UK*	Percentage contribution: Developed countries	Percentage contribution: Developing countries
Beef	47	1	24	11
Sheep and goats	7	0·25	2	3
Pig	51	0·9	25	14
Poultry	28	0·75	15	6
Total	133	2·9	66	34

*Meat and Livestock Commission (1982).

(Ahrens, 1979). In the UK, the Committee on Medical Aspects of Food Policy (Department of Health and Social Security, 1984) and the National Advisory Committee on Nutrition Education (NACNE) (1983) proposals offered firm and progressive guidelines on diet rather than determinants of national policy.

Whether or not it is this debate which has stimulated individuals to change their diets, change there undoubtedly has been. In particular there has been a reduction in the UK in daily energy intake and in the consumption of dairy but not meat and meat products (National Food Survey, 1986). These trends can be seen in other countries, e.g. USA (Table 2), though uniquely there has been no accompanying decline in deaths from coronary heart disease in the UK (Department of Health and Social Security, 1984). Indeed, Scotland and Northern Ireland now have the highest incidence of death from this syndrome and the numbers continue to rise.

It is this kind of finding and the uncertainties of interpretation of population information that have led to a relaxation in dietary recommendations in the USA, with an emphasis on eating a variety of foods of nutritional quality and in a quantity adequate to maintain reasonable body-weight (Harper, 1981). Importance is attached to minimizing the intake of fats over all, without special concern for their chemical composition or source, and emphasizing the energy density of fat and its potential contribution to body-weight gain.

The movement away from fat has been well established over recent years for today's consumers, unlike their parents and grandparents, prefer their meat to be much leaner

Table 2. *Food energy available and source (From Olson, 1981)*

Year	Energy available (kJ (kcal)/person per d)	Contributions (%) from: Protein	Fat	Carbohydrate
USA				
1909–1913	14 600 (3490)	11·7	32·1	56·2
1935–1939	13 680 (3270)	10·9	36·3	52·8
1965–1970	13 220 (3160)	12·1	41·0	47·0
UK 1980	12 680 (3031)	11	38	45
NACNE (1983) preliminary recommendation	12 680 (3031)	11	34	50

NACNE, National Advisory Committee on Nutrition Education.

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Table 3. *Expenditure on 'meat' convenience foods in the UK (pence/person per week) (From National Food Survey, 1986)*

	1975	1980	1985
Canned meat and meat products	6·2	9·4	11·8
Frozen meat and meat products	2·5	8·2	14·3
Other 'convenience' meat and meat products	16·6	33·5	49·9
Total	25·3	51·1	76·0

(Rhodes, 1976), though even the most health- or weight-conscious may well indulge themselves on paté and other delicatessen foods which contain appreciable amounts of fat (National Food Survey, 1986). The animal and meat industries have recognized these changes in eating habits and have responded in a variety of ways, for not only is it desirable to reduce the fat content of meat to satisfy consumer demand, but reducing the amount of fat deposited in the animal body is one of the most effective means of improving the efficiency of growth.

The dairy industry's response to these changing needs, both in terms of the quantity and composition of product supplied, is largely for control by production quotas or by novel process technology and has been well covered by Roberts (1988). Opportunities for the meat sector, however, provide even more scope for novel approaches both in animal production and process technology.

Consumer requirements

Today's consumer has more money to spend on food and, since more wives are in paid employment, less time to prepare food or even to think about diets and menus. There are, therefore, sizeable repercussions for the type and range of foods and food products on offer. For example, convenience and speed of preparation are important for working families and the use of freezers and microwave cookers assumes greater importance (Table 3). Predictability of quality and value for money are of paramount importance and increasingly there is a demand for foods to be 'wholesome' or 'health-giving'.

The growth of multiple retailing to include meats requires a greater range of products and different marketing approaches to tempt purchasers. Increasingly meat is required to be sold as another supermarket line which, like detergents and cereals, must be processed, packaged and presented in ways which appeal. The production and marketing of poultry meat typifies this trend and the success of the poultry sector is readily apparent (Table 4). Poultry meat is perceived to be good value, predictable in quality, highly acceptable to young customers and to require little selling by butchers; it is now sold

Table 4. *Daily consumption of meat (g) (From National Food Survey, 1986)*

	UK			USA*
	1965	1975	1985	1979
Beef and veal	30	31	26	47
Mutton and lamb	24	18	12	<1
Pork	12	12	14	21
Poultry	15	24	28	75
Total	81	85	80	153

*From Olson (1981).

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Table 5. *Production, estimated market demand and estimated consumer demand for beef carcasses in Great Britain (From Kempster* et al. *1986 and A. J. Kempster, personal communication)*

	Distribution of carcasses between EEC fat classes* (%)					Separable fat in carcass meat (%)	Fat trim before consumption (%)
	1+2	3	4L	4H	5L 5H		
Production (1984)	6	29	42	19	4	22	16
Market demand	5	55	25	13	2	20	13
Consumer demand	20	70	8	2	—	17	10

EEC, European Economic Community.

*Carcass fat, subjectively assessed: Class 1 and 2, 3%; class 3, 6%; class 4L, 8·25%; class 4H, 9·75%; class 5L, 12%; class 5H, 15%

increasingly as joints or pieces and as further processed items which yield a great variety of products to offer and greater added value.

Idustry's resonse

The meat industry is obliged to be schizophrenic about fat. There is a long-held belief by butchers and chefs, which influences the domestic cook, that fat is an essential component in the cooking process if meat is to acquire succulence, tenderness and flavour. There is even concern at the present time by leading retailers about the eating quality of pigmeat which is supposedly in decline as the amount of intramuscular fat decreases. This forms the background of the continuing tradition for judging the suitability of a steer or lamb for slaughter and its value on the basis of 'finish' or the amount of subcutaneous fat covering the carcass. There is also a net demand for animal fat for patés, sausages, pies and other products which requires its importation. Thus tradition and commercial interest ensure that fat production is maintained despite medical opinion and growing consumer demand for leaner products.

The gap between what the consumer wants and what farmers produce is illustrated in Table 5, which shows the percentage of beef-fat surplus to need at the point of production, at retail sale, and based on consumer need. Thus if beef were to contain 6% fat as the level desired by consumers, the surpluses would be between 10 and 16%, which would require a substantial change in the proportions of carcasses classified in the leaner ranges (i.e. classes 3 and 4L (see Table 5)). At these levels of fatness there is no evidence of poor eating quality. Indeed, whilst it is recognized that there may be a threshold concentration of intramuscular fat required for maximum consumer satisfaction, it is almost always exceeded in commercial carcasses (Rhodes, 1976). Evidence from recent consumer trials using pigmeat of varying fatness (Meat and Livestock Commission, 1987) showed that overall acceptability was not different between fatter and leaner samples, although the meat from the fatter pigs was more succulent.

There seems little doubt, therefore, that the fat content of carcasses and meat could be reduced without prejudicing acceptability by consumers, and Jones (1985) has calculated that the short-term recommendations of NACNE (1983) can be met without impairing the energetic efficiency of lean-meat production.

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Reducing carcass fat

Cutting procedures.

If fat is present in carcasses and joints of meat in excess of requirement then the simplest way of dealing with it is to cut it off, and this can be done anywhere between the abattoir and the plate. Butchers have long been skilled in trimming joints of meat to make an appealing presentation. Practices such as 'Supertrim' introduced by the Meat and Livestock Commission take conventional trimming practice further to yield lean cuts of beef and pork containing about 6% of fat (see Harrington, 1988).

Fat is, however, more easily removed from some carcasses than others. Pig carcasses may be fatter on average than beef or lamb (Kempster *et al.* 1982), but they present fewer cutting problems, because the bulk of fat is conveniently deposited subcutaneously from where it may be readily stripped. Beef and lamb carcasses contain larger amounts of intermuscular fat, which may not be difficult to separate from the separated muscles of beef, but quite impossible to remove from, say, a shoulder of lamb which is sold intact.

Changing practices in animal production

Animals of whatever species grow at different rates to different mature lean-body sizes, but there are common relations (Taylor, 1980). The efficiency of growth and the composition of carcasses at the chosen slaughter weights are functions of these. The practical consequences have led to the increased use in beef production in the UK, for example, of continental breeds of cattle, such as Limousin, Charolais or Simmental, which typically have a large adult size and late maturity, i.e. delayed fat deposition, and cause extremes of leanness at the usual slaughter weights. The same biological principles are germane to most contemporary thinking about increasing leanness in meat species by selection and breeding.

Given these prescribed relations, a further way of improving growth efficiency and carcass lean is to limit slaughter weights to those at which fat deposition has not begun to accelerate. Fowler (1976) calculated the changes in energetic costs which would result from changing various metabolic, reproductive and weight characteristics in a 90 kg pig. Reductions in, for example, the cost of protein synthesis or heat production by 10% led to savings of about 2%. Changing the weight at slaughter by 10% had a greater effect and a reduction of slaughter weight to 60 kg had even more, producing a saving in energy cost of about 15%.

These potential savings are readily transferred to practice, and Jones (1985) discussed the consequences of reducing slaughter weight for cattle and the influence of breed, and Wood *et al.* (1980) considered the consequences of similar manipulations in sheep.

The farmer's route to increasing the leanness of carcasses is prospectively by changing breed or slaughter weight, or both. In practice the latter requires the support of the abattoirs and wholesalers whose traditional approaches are difficult to dislodge and in the short term this approach would be difficult to develop. Indeed, the pricing of lamb carcasses is such that a heavier, albeit fatter, carcass may provide a better return to the producer than a lighter, leaner carcass.

Some novel and not so novel ways of changing carcass leanness

The poultry industry is noted for recognizing and responding to challenges and opportunities. The progress achieved by the poultry sector in improving the performance and somatotypes of stock by introducing new genotypes, by selection and breeding, and by exacting standards of nutrition and housing are well known (Wilson & Lawrence, 1985). It must be recognized, however, that the chicken has many advantages over other farm animals, for its physiology allows a formidable rate of reproduction and large populations can be maintained under controlled conditions for practical purposes, or for research on, say, feeding, breeding and housing.

The pig industry has never been far behind the poultry industry in the progressive improvement of the performance and carcass quality of its stock. Table 6 records the annual genetic changes observed in pig performance and shows the progress made in carcass leanness which contributes to both growth efficiency and financial gain. A particular advantage to the pig industry, on which much of the progress depends, is the ability of traders to predict the lean in a carcass of particular weight from a knowledge of the backfat thickness which is easily measured. Contracts may thus be drawn up between producer and abattoir which reward producers in an objective way according to the predicted leanness of the carcass. The benefits are such that today more than 80% of pigs are sold direct to slaughterhouses, rather than via livestock markets, where it is impossible to make objective evaluations of carcass merit. It is probably because of the difficulty of measuring or predicting the composition of ruminant carcasses with adequate accuracy that progress towards improving the leanness of their carcasses has been slow. It is also this inability which has preserved live animal trading via markets as the predominant feature of beef and sheep production, and one which is likely to remain until better procedures are introduced to reward carcass leanness or penalize fatness on more objective bases. There are opportunities to improve the prediction of the carcass composition of ruminants by, for example, the use of measurements of the velocity of ultrasound in body tissues or the use of X-ray computed tomography (X-ray CT) or nuclear magnetic resonance (NMR) imaging (see Lister, 1984). The first is currently being assessed in trials in factories (Agricultural and Food Research Council, 1987), but there is little prospect for the others so long as their capital and running costs remain high and difficulties with information handling persist. Progress in improving ruminants will, however, continue to be slow until better techniques are available for describing objectively the composition of the bodies of potential breeding animals.

Breeding

Progress in conventional animal breeding is slow (approximately 2% per year), but in recent years new approaches have been devised which hold considerable promise (Land, 1985). So long as the number of offspring from cattle only rarely exceeds one at the end of a pregnancy lasting 9 months, breeding progress must, of necessity, be slow. Artificial insemination and the frozen storage of semen can accelerate progress but even greater steps can be made with the multiple ovulation and embryo transfer (MOET) technique,

Table 6. *Estimates of annual genetic change in pigs in the UK (From Aumaitre* et al. *1982; Mitchell* et al. *1982)*

Selection objective	Estimated annual genetic improvement	Monetary value (pence/pig per year)	Percentage of total improvement
Feed conversion efficiency (kg intake/kg gain)	0·027	23·2	31
Daily gain	5	3·4	5
Eye muscle area	0·27	0·8	1
Killing-out (%)	0·11	6·9	9
Trimming (%)	0·08	4·4	6
Lean in side (%)	0·68	37·6	49
Total	—	76·0	100

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by means of which several fertilized ova obtained from superovulated donors may be individually transferred to recipients for carrying until term. It is possible by this route to obtain twenty to thirty calves/year from one donor cow.

Developments in molecular biology have enabled us to consider entirely novel approaches which can be used together with conventional breeding techniques to improve the performance of all stock (Cundiff, 1984). Transgenic animals (Wagner, 1986) in which genes of interest in a production context, e.g. to increase milk yield or live-weight growth, are inserted into the recipient animal's genome, offer considerable potential. The techniques required have been developed in rodents and are only now being attempted in farm animals. The two methods currently employed are gene injection into one- or two-cell embryos (which is the most commonly used technique) or, perhaps of greater promise, retroviral infection (Brinster *et al.* 1985; Palmiter & Brinster, 1985). Of particular interest to animal production are the genes coding for pituitary, hypothalamic and liver polypeptides, leading to the stimulation of growth hormone, growth-hormone-releasing hormone or somatimodin C, but satisfactory practical results in farm animals have yet to be produced (e.g. Hammer *et al.* 1985).

The use of male animals

For centuries it has been common amongst many cultures to castrate farm animals of both sexes to avoid unwanted pregnancies, to curb the behaviour of males and to make draught animals more amenable. The extra fat which such animals deposit was welcomed by communities which required lard and tallow for winter food, fuel and lubricants. In more modern times, the propensity of males to grow fast, lean and efficiently (Rhodes, 1969) has assumed greater importance and bulls, boars and rams are raised intact for meat in several parts of the world, though practices vary widely. Within the EEC, bulls are raised for meat in large numbers in Italy, France and Germany, but few are reared in the UK and Eire. The use of boars for meat is the rule in Australia, whereas only slightly more than 50% of males are kept intact in the UK. In Denmark no boars are reared for meat. Male lambs are rarely left intact in the UK, whereas there is active encouragement of the practice in New Zealand (Ministry of Agriculture and Fisheries, New Zealand, 1983). More widespread use of male animals could contribute significantly to lean-meat production, if the bases of objection to their use could be objectively identified.

Only in the case of pigs is there a well-founded argument against the use of males for meat, and this is based on the aroma which some people, mainly women, find objectionable when the meat is cooked (Rhodes, 1971). Beef from bulls risks bacterial spoilage and being 'dry' to eat because of the propensity of bulls to produce so-called dark cutting meat, but this can be avoided by careful handling of the animals before slaughter (see Hood & Tarrant, 1981). There are neither taints nor serious carcass defects in ram lambs (Butler-Hogg & Brown, 1986).

The steroid androstenone is a major, if not the most important, component of boar-taint (Patterson, 1968). It is produced in the testes and found in saliva and in greater concentration in adipose tissue. Active immunization of boars against androstenone is effective in reducing its concentration in fat and the incidence of taint in the meat (Williamson & Patterson, 1982). There is every prospect that this technique could be developed for the effective control of boar taint, but there is little incentive to do this for, despite the acknowledged risk of complaints about taint, the acceptability of boarmeat continues to increase, albeit slowly, within the trade.

If bulls could be produced using conventional management rather than under intensive husbandry systems then more bulls might be raised. Robertson *et al.* (1984) proposed that immunizing young bulls against luteinizing-hormone-releasing hormone (LHRH)

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would provide a suitable alternative to surgical castration, and hopefully eliminate the behavioural problems of bulls whilst retaining the desirable growth and carcass attributes of the intact male. The experiments conducted showed that the more effective the immunization the more steer-like bulls became, taking on the behavioural characteristics of the castrate, but unfortunately becoming fatter than the untreated bull. Somewhat similar results have been found when the technique is use in boars, and there is an additional reduction in the incidence of taint in the meat (Falvo *et al.* 1986). It might be possible to immunize animals with doses which balanced behavioural effects and carcass composition optimally, but once again traditional attitudes and production methods may counter interest in a technique which adds cost and could receive critical scrutiny on welfare grounds.

Hormone growth promoters

A wide variety of hormonal agents, drugs and manipulative procedures have been used to try to improve the growth, efficiency and composition of meat animals (Roche & O'Callaghan, 1984). The use of natural and synthetic steroids in ruminants is a prime example and their application ranges from calves to culled dairy cows, though their efficacy varies from impressive (in veal calves) to marginal (in bulls). Heifers and castrated males respond well to androgenic or oestrogenic hormones respectively or, in some cases, combinations of the two, but the treated steer rarely performs as well as the intact male (Fisher *et al.* 1986).

There is no doubting the commericial success of these anabolic agents in cattle, but there is concern from consumers about longer-term dangers of eating meat from treated animals, and though the scientific evidence is reassuring (Lamming *et al.* 1987), ministers of the EEC have banned the use of both natural and synthetic steroids within the Community. Their use is still permitted, however, in North and South America which complicates 'Third Country' trading.

Adrenergic agonists

The sympathetic nervous system has been recognized for some time as an important regulator of metabolic function, but associations with body type have only recently been identified (Gregory, 1981). Latterly, particular anabolic effects of sympathomimetics have been observed and considered for practical application as tissue-repartitioning agents and a means of increasing the leanness of carcasses (Stock & Rothwell, 1986). Clenbuterol, a β_2 adrenergic agonist, has been examined in poultry, cattle, sheep and pigs (Dalrymple *et al.* 1983; Baker *et al.* 1984; Ricks *et al.* 1984). There is abundant evidence for the repartitioning effect of clenbuterol, but effects on live-weight gain and feed conversion efficiency are less clear-cut.

Cimaterol (Boehringer Ingelheim), another β-adrenergic agonist, has also been investigated and a similar picture emerges (Beerman *et al.* 1986).

It is generally proposed that the action of these agents is via their lipolytic properties which reduce carcass lipid (Thornton *et al.* 1986), but there is much debate, and workers at the Rowett Research Institute, Aberdeen (W. P. T. James, personal communication) suspect a particular effect on protein anabolism and there is evidence of a lean-inducing effect in cattle (Allen *et al.* 1986). The half-lives of some of these drugs questions their value in animal production, for the withdrawal periods before an animal's slaughter for meat could be so long that the beneficial effects of the drug may be lost. There is, therefore, a need to tailor pharmacological, physiological and practical characteristics of such drugs, and the development of so-called designer drugs is a prospect. But, as is the case for the more conventional hormonal growth promoters, political judgements may be

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more important than drug efficacy in determining whether these agents may be used in meat production.

Somatotrophin (ST)

The use of bovine somatotrophin (BST) is predicted to be widespread in the USA by 1989 (Wright, 1987) as a means of improving the milk yield of dairy cows by as much as 25–30%. The superior performance is thought to be achieved by the same physiological and metabolic routes used by cows that are genetically superior in milk production. This, together with the knowledge that BST is not physiologically active in man, may allay fears of its safety and, hence, acceptability to milk users. BST can also be produced by recombinant DNA technology.

The same arguments have been used to support the use of ST as an anabolic agent in meat animals. But so far the results of experiments designed to examine these properties have been equivocal (for review, see Hart & Johnsson, 1986). Effects on body composition are more marked than effects on growth and feed conversion efficiency, but responses differ from one species to another and according to the species of somatotrophin used, i.e. bovine, porcine, human or recombinant DNA derived. In general, there seems to be potential for using somatotrophin to reduce the fat content of the carcasses of pigs (Etherton *et al.* 1987) and sheep (Muir *et al.* 1983), but there is too little information available to predict any use in beef production.

Growth-hormone-releasing factor (GRF) (Guillemin, 1983) offers a way of modifying the endogenous production of somatotrophin and hence a possible means of manipulating growth and body composition. Reports on its use in pigs (Etherton *et al.* 1986) have again been equivocal, and more research is needed to define mechanisms of action and suitable means of delivering the peptide before appreciable progress can be made towards its application in meat production generally.

Immunological control of growth

An alternative strategy to the use of passive hormone therapy for manipulating growth is to derive immunogenic complexes to produce active immunity to a particular hormone, or transfer the antibodies produced to a recipient in the hope of controlling the action of that hormone on other endocrine tissues. This procedure has been used to produce antibodies to somatostatin (SRIF) which neutralize the endogenously produced hormone and its inhibition of somatotrophin (Spencer, 1986). Early experiments with this procedure on a primitive breed of sheep (St Kilda) showed important improvements in growth and feed conversion efficiency, but trials with contemporary breeds have not been so successful.

This finding reflects many of the scientific and practical difficulties to which many such novel approaches are heir. There is, for example, a lack of knowledge of the sensitivity or tolerance of the immune system to immunological complexes in populations, which leads to enormous variety (and, hence, statistical variability) in responses. Species vary in responsiveness and the usual laboratory models may not be relevant for farm animals. Moreover, the commonly used adjuvants and delivery systems may not be acceptable in farm and food practice.

SRIF is known to have a wide range of actions which are crucial in the control of metabolism, nutrient utilization and growth, and it would be unwise to dismiss the approach entirely until many of the basic problems associated with immune reactions and immunity generally are themselves solved.

Antigens and antibodies may be used in a range of ways to manipulate hormone secretion and action to control growth and metabolism (see Perry, 1983). Hormones may be used, for example, to act as carriers of toxins to specific sites in tissues. Plasma cell membranes can be considered as suitable targets and they may also be used in the preparation of antibodies to specific cell types, e.g. adipocytes, such as Vernon & Flint (1988) described to reduce the development of individual fat depots in the body. This technique seems to be most applicable to simple-stomached animals and, indeed, it is not clear what use could be made of the acetate produced in the ruminant digestive process if it were not allowed to be deposited as fat.

Diet, health and agriculture in context

The argument was put earlier that the diet–health issue is better considered as yet another, albeit important, element in agricultural progress. There is no doubt that dietary habits have changed in the Western world in recent years, though whether this is a consequence of changing lifestyles, employment, wealth or concern about health, cannot be identified. Diets have always been changing (see Olson, 1981) and it is interesting that contemporary recommendations on nutrient intake are very similar to what the average American consumed in the late 1930s. Whatever the stimulus, the agricultural and food industries have reacted and the range and type of food products available have never been greater. Where the difficulties and debate are most controversial is in whether the agricultural and food sectors should respond specifically to a community's interest in, say, dietary fatty acid profiles, organically-produced food or 'hormone-free' meat and develop strategies for future plant and animal production to meet them. Whilst these matters are, to some, issues of monumental concern, to others they pall into insignificance beside the problems of overproduction of food in some parts of the world and famine in others, the high cost of agricultural support to maintain a stable farming community, or the high social and political cost of not supporting it. The implications for world agriculture of changes in EEC or United States agricultural policies could be devastating (Oliver, 1986). Thus the major pressures for change in farming polices and agricultural and food developments come not from nutritional or health pressures, but from the need to maintain foreign trade relations, farm incomes, preservation of the environment or the public's view on the welfare of animals used for food (Reid, 1985; Bennett, 1987). The importance to be attached to each or any depends also on the political 'clout' which can be mounted to support or deny, which depends neither on science and economics nor altruism.

The key question remaining is whether it is feasible politically for governments to intervene by price or other mechanisms to engineer a national diet and stimulate a response from the agricultural and food industries. It will be interesting to monitor the progress of the Norwegian government's intention to manipulate the national diet almost independently of an agricultural policy designed primarily as a social policy to keep people on the land (Thelle, 1988).

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Printed in Great Britain