The future role of grass in the food chain

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The role of grassland

Grasslands serve and have served many different purposes in the world, some of them related to the control of soil erosion and some to various aspects of amenity. Grass itself, however, even when widely interpreted, has generally served as an intermediary product in the human food chain.

This distinction is likely to continue to be important, at least in terms of the role of grassland and the role of the grass product being different. Expressed another way, one of the roles of grassland is to produce a product but there are other roles and these may even be extended in the future. Natural grasslands might well serve as catchment areas, for example, for both wind and water (extremely likely) and even a receiving surface for solar radiation (less likely), other than in the form of plant cover. In such cases, of course, there is no reason to suppose that grass products could not also be harvested, although use as a catchment area does sometimes impose constraints on, for example, grazing.

More important, perhaps, is the possibility that these 'grassland' roles could affect the economics of the grass production process, simply because another use of the land would result in a sharing of some of the overhead costs.

The same argument also applies to multiple use of smaller areas of sown grassland, as in the possibility of grazing ruminants or geese in orchards or even the use of poultry (feeding more, perhaps, on insects than herbage) or even pigs (perhaps with an additional function of discouraging vandals and other marauders).

The simple fact is that multiple use may have some effect on the economics of grass production and utilization and thus influence the form of the latter. The aim of this paper is, having recognized the foregoing, to focus on the role of grass.

The role of grass

Traditionally, the role of grass has been overwhelmingly as a ruminant feed, mainly harvested by grazing. Such harvesting is not without its energy cost, particularly on sloping land, but it may be regarded as using solar radiation, at least indirectly. Other possibilities exist, however, and include utilization for food by non-ruminants (including man and invertebrates), with or without processing, and the use as a source of fuel (see Fig. 1). Virtually all of these other possibilities involve harvesting by man, with or without machines, although grazing by some non-ruminants is certainly feasible. Feasibility is only one of the determinants as to which of these forms of utilization will actually occur in the future. The issue is not

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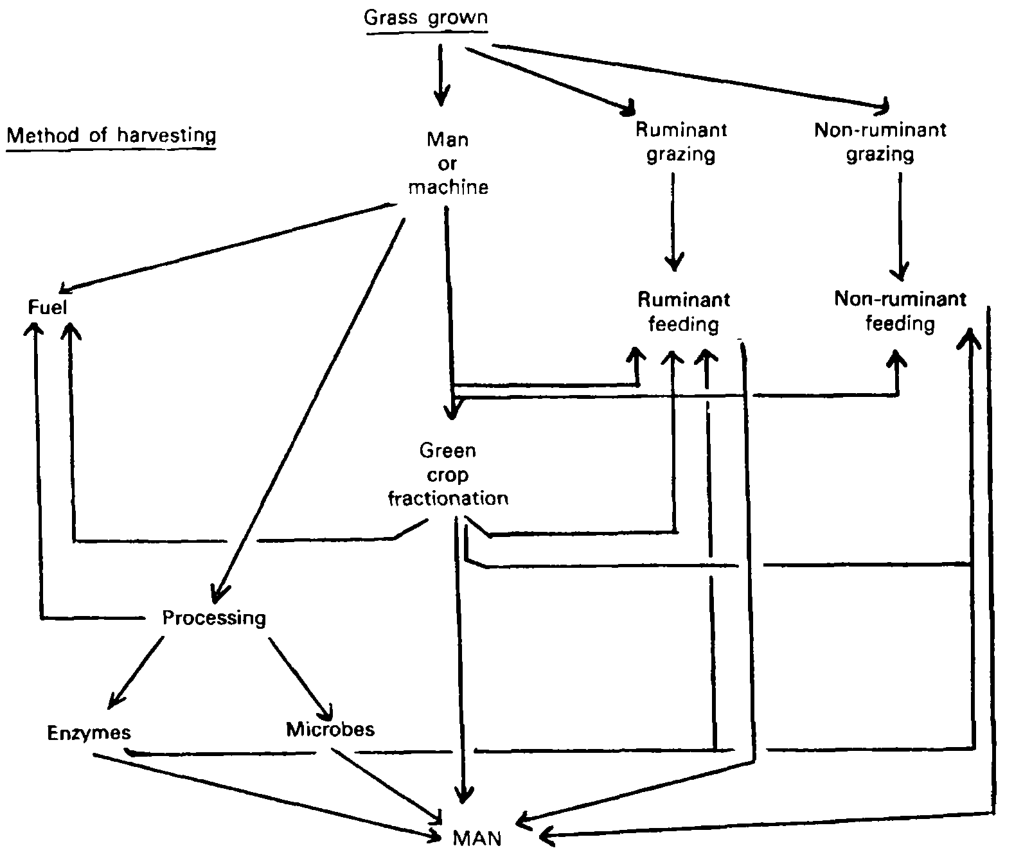

Fig. 1. Schematic representation of the 'Grass' food chain.

much helped by regarding it as simply or solely determined by economics, since the relevant future costs and prices are not known. It is possible to argue that, in these circumstances, energy accounting is more relevant, on the assumption that energy costs will rise and will dominate all other costs. In fact, energy costs may be said to dominate all other costs now, unless the labour input is very high and is costed separately.

On this view, those processes that involve high energy costs per unit of product will be less likely to be operated but that is clearly not the case currently, since animal production is, in general, about one-fifth as efficient as crop production (Table 1) but commands a disproportionately higher price. Even so, it is worth considering the relative efficiencies of energy use in the production of, for example, energy and protein by different forms of grass utilization (Table 2). In some cases, these processes are not yet well developed and thus significant improvements may be possible. So perhaps it is more realistic and useful to consider what possibilities should be further explored, rather than attempt to predict the outcome.

Table 1. *Efficiency (E) of production and the value (P) of products**

Production system	E	P: World price (1973)	P: UK price to farmer (1974/75)
Yams†	430		
Rice	8–16	0·94	
Cassava†	140		
Maize	14		0·64
Sorghum	33		
Barley	21		0·62
Oats	20		
Wheat	28	0·22	0·53
Milk	7·3	1·95‡	1·43
Beef	1·7	3·22	4·06
Sheep meat	2·5		5·43
Green crop fractionation			
Beef + leaf protein concentrate (LPC) for humans	3·5		
Beef + LPC for poultry	0·76		

$$E = \frac{\text{Protein output (kg)}}{\text{Support energy input (GJ)}}.$$

P = Price (in £)/kg of protein.
*After Spedding, 1979; Spedding *et al.* 1980.
†Subsistence crops grown in Fiji.
‡Evaporated milk.

Apart from rather small areas of grass, it seems unlikely that grazing will be the method of harvesting, except by ruminants, and in their case this may seem likely to be the main method of utilization. For other uses (than by ruminants), it seems likely that (a) harvesting will generally be by machine and that (b) some form of processing will follow, since fresh grass is of little use to man directly. Four major kinds of processing may be envisaged: for fuel, for conversion to human food, by fractionation and by non-ruminant animals.

Processing for fuel. The net energy output of grass (i.e. the gross energy minus the fossil fuel energy input) is of the order of 180–270 $J \times 10^9$/ha, and both

Table 2. *Relative efficiency (E) of energy use in the utilization of grass**

Method of utilization	E
Milk production	0·33–0·62
Beef production	0·11–0·18
Lamb production (including wool)	0·23–0·39

$$E = \frac{\text{Gross energy output}}{\text{Support energy input}}.$$

*After Spedding, 1979.

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perennial ryegrass and Italian ryegrass feature in the list of potential fuel crops for the UK (Spedding *et al.* 1979). The net energy output could probably be improved by growing grass in association with legumes, since this would greatly reduce the support energy cost of fertilizer inputs.

It has been estimated that if the whole of the UK agricultural land were sown with grass yielding 10 t DM/ha, an annual output of methane equivalent to approximately 86×10^9 J/ha could be obtained. Subtracting the necessary energy inputs would leave a net output of 60×10^9 J/ha or 726×10^{15} J in total per annum (Blaxter, 1977). This represents about 8% of 1977 UK energy consumption and would mean foregoing most of our home-produced food. However, grassland not needed for animal production could nonetheless produce significant quantities of fuel and this possibility should not be excluded.

Conversion to human food. Relatively little thought yet appears to have been given to the possibilities of microbial or enzyme treatment aimed at the conversion of grass to food for direct human consumption. The main reasons for thinking about it are the large yields of grass obtainable/unit of land, relative to those of other crops (Table 3), and the low efficiency with which animals usually convert grass to meat and milk (Tables 1 and 2).

Fractionation. The idea of leaf protein extraction (Pirie, 1971, 1978) is well established but, in recent years, the term 'green crop fractionation' has been preferred, largely in recognition of the fact that the economics of such processing must rest on efficient use of all the fractions produced (Wilkins, 1977). Possibilities already considered include the use of the liquid fraction for feeding to pigs (Braude *et al.* 1977), and the use of the fibrous residue for feeding to cattle (Pirie, 1978) or as a source of fuel (McDougall, 1979). This last notion reflects the need to reduce the fuel costs of processing and is a good example of the central dilemma of agriculture, including the use of grass: that is, how to use biomass more efficiently without recourse to large amounts of fossil fuel. Where processing leads to increased efficiency of other resource use (especially land and labour), a substitution of biomass for oil as a source of fuel seems increasingly likely to make economic and energetic sense.

Conversion by non-ruminants. There would seem to be little sense in feeding unprocessed but harvested grass to non-ruminants except in relatively small

Table 3. *Yields of grass and other high-yielding crops*

	Yield	
	DM tonnes/ ha per year	Energy MJ/ ha per year
Perennial ryegrass	5–12	92 000–218 000
Wheat grain	3	58 600
Potatoes: tubers	6–11	100 400–188 000
whole crop	13	223 000
Sugar beet: roots and tops	16	264 000
roots only	10	174 000
Kale forage	7	126 000

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Table 4. *Feed conversion by the grass carp* (Ctenopharyngodon idella) *compared with that of cattle and rabbits**

	Rabbits†	Cattle: Dairy‡	Cattle: Beef§	Grass carp*‖
Protein¶ (kg/100 kg grass protein)	28	17	10	38
Energy (MJ/100 MJ grass)	15	13	7·7	17
Annual output of protein (kg/ha per year)	560	340	200	760
Annual output of energy (MJ/ha per year)	28 000	25 000	15 000	32 000

*Yields of energy and protein are based on whole body and not just the edible portions.
†Assuming fifty progeny/doe per year.
‡Assuming five lactations, each of 5000 kg milk/cow (and including calves and culled cows).
§Assuming beef from the dairy herd.
‖Based on feeding experiments in aquaria at 20–24°.
¶Calculations are based on perennial ryegrass yielding 10 000 kg DM/ha per year.

quantities or, in general terms, where there is no practicable way of feeding it to ruminants.

The seasonality of grass growth does give rise to problems in feeding warm-blooded animals and there may be some scope for making use of the poikilotherms' reduced susceptibility to sporadic feeding. Thus fish, especially herbivores such as *Tilapia* spp. and *Ctenopharyngodon idella* (the grass carp), snails, slugs and insects might be employed to use grass (and other vegetation) available unevenly and, perhaps, not even in a fresh state. Very little has yet been done to explore these possibilities but initial indications suggest that this might be worthwhile (Table 4).

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