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Notes on the workshop session

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These notes do not represent agreed conclusions. They are a purely personal attempt by the chairman of the workshop to summarize what seemed to be the general consensus of those who were present. Individual members of the group may well disagree with some or all of the points which follow. *A fortiori*, these notes do not represent a judgement or conclusion reached or accepted by the Nutrition Society.

Species

The principal species covered by the discussion were those members of the family Leguminosae (Fabaceae) which are grown for their edible fruits or seeds in which the energy reserve is starch rather than oil. However, the oil-rich legumes, soya bean and groundnut were considered during the symposium itself, and some of the information used in the workshop came from these species. The principal genera in mind were ***Phaseolus***, ***Vigna*** (including the Asiatic species formerly assigned to ***Phaseolus***), ***Pisum***, ***Vicia***, ***Cicer*** and ***Lens***, which are grouped as the pulses in the FAO production tables.

Output and contribution to protein supplies

The total outputs of cereals, soya bean, groundnuts and pulses in 1979, and the approximate amounts of protein they contained, are in Table 1.

Important as pulses are in diets, particularly in the poorer countries, their contribution to total protein supply is much smaller than that of cereals. Even in the poorer countries it is no more than 10%. However, they tend to complement cereals in amino-acid composition, which may be nutritionally useful in poorer communities. They are also valuable, particularly in vegetarian societies, as sources of variety in otherwise monotonous diets. Except in the Far East, soya-bean protein is mainly consumed by livestock and so helps (at the cost of large conversion losses) to increase the supply of animal protein in human diets—particularly in the affluent societies.

Table 1. *Output and protein content (millions of metric tonnes) of cereals, soya bean, groundnuts and pulses, world and developing countries* (1979)

	Output		Protein	
	World	Developing countries	World	Developing countries
Cereals	1553	753	153	74
Soya bean	94	30	36	11
Groundnuts	14	13	4	4
Pulses	52	41	13	10

Future needs

The human population of the world is around 4500 million at the present time. About 3200 million live in the developing countries. In the year 2000, at least 4500 million of an expected total of 6200 million humans will live in these countries. In the world as a whole the effective demand (including subsistence consumption) for pulses may be 75 million tons, of which 60–65 million may be in the poorer countries.

Though the harvested area of pulses may increase somewhat, the main component of the extra output will be the increase in yield per harvested hectare. The present yields of pulses are around 1200 kg/ha in the developed countries and 600–650 kg/ha in the developing countries. The demand for 60–65 metric tonnes/year in these countries in the year 2000 would be met if average yields were to increase to around 1000 kg/ha. This seems feasible technically, since the practical potential yield, given effective crop protection, is already of this order. It may well be attainable in practice if commodity prices are sensibly managed and controlled.

Undesirable attributes of grain legumes

Grain legume seeds (and perhaps other parts of the plant as well) contain protease inhibitors, lectins (haemagglutinins), condensed tannins and other nutritionally or physiologically undesirable heat labile substances. They may also contain toxic alkaloids and toxic non-protein or other unusual amino-acids, cyanogenetic glucosides, fermentable carbohydrates (flatus factors) and other undesirable heat stable compounds. If they were not natural products, they might be banned by agencies such as the Food and Drugs Administration.

The biological functions of the undesirable substances in the seeds are far from fully known. They generally increase, along with hardness and other attributes which increase cooking time, as the seeds mature. There is no evidence for the surmise that protease inhibitors are useful in conserving reserve protein as it is laid down. There is evidence in some cases, and surmise in others, that some or all of these substances (which are presumably there for adaptive reasons) help to protect the nutritionally attractive seeds against bacteria, fungi, insects, birds and mammals. They do not seem to do this very well. The evolutionary strategy seems to have produced several different and relatively general defence mechanisms, none of which is necessarily effective in any one specific situation. More research is needed to determine the biological significance for the plant of these substances and attributes and hence to assess the extent to which it is sensible to attempt to offset them by breeding.

The physiological effects on humans, in practice, of these undesirable constituents and attributes are also not completely known. Favism and lathyrism have been well, even if not sufficiently, studied. Protease inhibitors induce hypertrophy of the pancreas in rats when fed in very large amounts, but there is no evidence of an effect on human beings. Lectins can cause food poisoning (for example, by raw or insufficiently heated red kidney beans) and damage the intestinal mucosa. Flatus factors lead to discomfort and embarrassment. Studies of the reactions and resistances of humans and other mammals to these constituents and attributes are needed.

Many of the effects can be offset, lessened or removed by appropriate preparation or cooking procedures, including those which are traditional in developing countries. Among the most important adverse attributes are those which increase cooking time, as energy sources (including fuel wood), become increasingly scarce and expensive.

Nitrogen fixation

All legumes are devoutly believed, and some grain legumes have been proved, to fix atmospheric N_2 with the aid of symbiotic *Rhizobium*. They may devote a third or more of the energy proceeds of carbon assimilation to doing so. In grain legumes, most of this N is harvested in fruits, seeds, edible leaves and forage for livestock. Nevertheless enough is left over in the soil, in many circumstances, to provide a useful bonus for subsequent non-legume crops. Conversely, N fertilizers, appropriately used, often increase the yields of grain legumes.

Protein supplies, protein content, and amino-acid composition

The most direct ways of increasing the contribution of a grain legume to protein intake in human diets are to increase the supply and decrease the cost of the product, while maintaining or increasing the return to the producer, by increasing output per unit of land area and other necessary resources including labour, and decreasing transport and storage losses. To make the product more acceptable aesthetically or organoleptically to consumers helps to increase intake.

Considerable attention has also been given to protein concentration and amino-acid composition. Some heritable variation is available for both these attributes. Some, but not all, attempts to increase protein concentration have encountered a yield penalty. There is little or no information on the relation between yield and amino-acid composition. Where there are negative effects on yield, they are unlikely to be offset by larger prices for products which are thought to be more valuable nutritionally, particularly as authorities do not agree that there is clinical evidence of adverse effects on human health of so-called 'deficiencies' in the amino-acid compositions of either legumes or cereals. Even if there is, it cannot be easy to separate such effects from those of the general undernutrition with which suspected amino-acid imbalances must often be associated.

Consequences for plant breeding

The main task, for breeders who seek to increase the contributions of grain legumes to human nutrition and rural prosperity, is to produce more productive locale- and system-specific varieties and populations, which can increase the output per unit of land, labour, water and other resources used, in the actual environments and systems of production concerned. To do this breeders will seek to increase and stabilize yield/ha by producing a range of appropriately-adapted high-yielding varieties. Such varieties will be well-adapted to local environments and local populations of ***Rhizobium***; their morphological structure will favour larger yields; and they will be resistant (and will be maintained resistant by continuing breeding if necessary) to pests and diseases. Many will be adapted, as many are already, to mixed and sequential cropping. Genetic diversity is already available—and is being vigorously evaluated, used and increased—for these purposes, particularly in the large germplasm collections of India and other nations, and of the International Agricultural Research Centres funded through the Consultative Group on International Agricultural Research. Breeders may also be able to decrease hardness and cooking time, and to increase acceptability by housewives and consumers.

They may also be able, if required, to breed against nutritionally and physiologically undesirable attributes, but to the extent that these attributes form part of the biological protection system of the growing crop, the stored product, or the seed for future crops, success may of necessity have to be limited. Where an agronomically-desirable attribute has to be introduced from a related wild or unimproved cultivated form, breeders will no doubt ensure that undesirable qualities are not transferred with it.

If at the same time the content of protein can be increased, and the amino-acid composition altered in ways which are clinically desirable, without loss of yield or other desirable attributes, those objectives, which appear to be secondary in spite of the attention they have attracted in the past, will no doubt be accepted by breeders.

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