Potential for Leaf Protein as Human Food

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Plant proteins are synthesized in the leaf and then partly translocated to seeds or tubers. In suitable climates, forage crops maintain a photosynthetically active structure throughout the year. Because of the elimination of translocation losses and the ripening period, forage can yield more protein and dry matter than any other type of crop, but this advantage is usually lost – the forage is fed to ruminants, and they convert only 5 to 25% of their feed into products that people eat. It is easy to extract 40 to 60% of the protein from many types of leaves, to separate palatable protein from the extract, and thus remove strongly flavored (or even toxic) leaf components from the curd. The annual yield of dry protein can be two tons per hectare in Britain and three in India. Unextracted protein remains in the fiber and this, because much of the water initially present in the crop is pressed out during the extraction, can be economically dried to make winter feed for ruminants.

Soft, lush leaves are easier to extract than leaves that are fibrous or dry; even when pulped with added alkali, acid leaves do not extract well; glutinous or slimy extracts are difficult to handle. In spite of these restrictions, there are many species that can be harvested mechanically and that regrow after cutting. The mixed growth on untended land is useless; if the growth could be harvested mechanically and if growth were to be encouraged by manuring, it would be better to sow a desirable species. Water weeds have potentialities, but little is known about the extractability of the protein in them. By-product leaves, e.g., bean, pea and potato haulm, and the outside leaves from vegetables, give good yields. Nothing, however, would be gained by extracting protein from edible vegetable leaves. Few communities eat them to an extent that is possible and desirable, and there is little prospect of popularizing leaf (LP) unless a community already makes ample use of leafy vegetables.

Protein-containing juice is liberated from leaves by rubbing and bruising; fine subdivision is inessential and may be detrimental. The gentler the pressure at which juice is expressed, the greater its protein content and the smaller the amount of fibre in it. Most of the protein used in human feeding trials was made in a high speed pulper coupled to a press. This arrangement is vulnerable and wastes power. Ideally, rubbing and pressing would proceed in one slow speed machine; we are making some progress towards a suitable design.

LP can be coagulated by acidification or heating. Heating is preferable because it partly sterilizes the curd and gives it a texture that makes filtration easy. The more sudden the heating, the better the texture and the smaller the risk from enzymic changes. A hazardous amount of pheophorbide may be formed if juice from leaves rich in chlorophyllase is heated slowly. Heating to 70 C suffices; heating to 90 C is preferable. The proteins associated with chlorophyll coagulate at 45-55 C (depending on species and pH). This green fraction contains 2/3 of the LP; its removal is sometimes advocated so that a pale preparation can be separated from the juice by further heating. The process is technically difficult, and delay in separating curd from "whey" facilitates the conjugation of protein with phenolic compounds in the "whey."

Curd that has been heated to 70 C filters off easily. Filtration becomes difficult when curd is resuspended in water at leaf pH 5.5-6.5, but it is easy if the suspension is acidified to ca. pH 4. Acidification ensures the removal of alkaloids, but it converts chlorophyll to pheophytin and increases the rate of oxidative loss of β-carotene. Furthermore, the dull green is less attractive than the bright color of neutral LP. If LP is regarded as something to be made on a farm, the defects of acid washing must probably be accepted. As an industrial product, LP could be washed centrifugally without acidification.

Whenever possible, LP should be used as a fresh presscake containing about 60% water. If made at pH 4, it has the keeping qualities of cheese or sauerkraut. For longer preservation, it can be salted, pickled, or canned. Drying, when that is essential, must be circumspect or the product will be dark and gritty. By using water-miscible solvents, drying can conveniently be combined with decolorization. Experience shows that decolorization is unnecessary; furthermore, it complicates a process that could be simple enough to be managed by unskilled people on a farm. Decolorization also removes useful unsaturated fatty acids, and β carotene.

Carefully made dry LP contains 60 to 65% true protein and 0.1 to 0.2% β carotene. Preparations differ slightly in amino acid composition, but these apparent differences may arise as much from the use of leaves of differing age and antecedents, or different processing techniques, as from real species differences.

Feeding experiments with chickens, mice, pigs, and rats showed that LP was safe and nutritionally useful. Four human trials have been published. A 50:50 mixture of LP and milk gave nearly as good nitrogen retention by malnourished infants as the same amount of protein given wholly as milk. Children 6 to 11 years old grew more on a diet supplemented with LP than on the same diet supplemented with lysine or sesame. Mothers gave 10 g of LP daily to a group of 2-to 6-year-old Nigerian children with kwashiorkor. Besides curing the children, this improved their appetites and mental alertness. The normal diets of four groups of children in south India were supplemented daily with 10 g of protein from milk, lucerne or legume seeds. Growth and state of health were assessed from time to time during two years. LP was marginally better than the legume seeds; as was to be expected, it was not as good as milk. These children lived at home and had considerable freedom in their choice of food; acceptance of green LP presented no problems.

The main merit of LP, compared with most other novel foods, is that it could be made in villages where, in the less developed countries, the need for improved nutrition is greatest. The importance of this is slowly being recognized by those concerned with planning. LP will not be used widely until more administrators realize that it is a good protein and potentially the most abundant in wet tropical regions. Acceptance would obviously be hastened if LP were known to be used by people with local prestige.

References covering all the points made in this paper are given in "Leaf Protein and Other Aspects of Fodder Fractionation," N.W. Pirie, Cambridge University Press, London, 1978.