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LPC is novel source of protein for human health and nutrition: A review

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Green vegetation is the primary replenishable source of food in the world; numerous technologies have been developed over the last 50 years to separate protein in leaf from accompanying fibrous material. The leaf extract or juice contains proteins, sugars, salts, lipids and vitamins along with the moisture in plant. When the juice is heated to over 80°C, or acidified to pH 4, green protein rich curd referred as leaf protein concentrate (LPC) is produced. The LPC can be separated from deproteinised juice (DPJ) by filtration through cotton cloth. In this way green foliage can be fractionated mechanically into three fractions: (i) fibrous pressed crop, (ii) leaf protein concentrate and (iii) deproteinised juice (Wilkins et al., 1977; Pirie, 1978).

During green crop fractionation the pressed crop residue (PCR) which is also known fibrous residue, left after the extraction of juice, still contain from 9 to 16 % crude protein (CP; N x 6.25) in its dry matter (DM) depending on the species used for fractionation. This can be successfully used as a feed for cattle (Walker et al., 1983; Joshi et al., 1983). Leaf protein concentrate (LPC) contain from 40 – 70 % protein (on DM basis) along with appreciable quantities of β-carotene (pro-vitamin A), vitamin E and minerals. The LPC can be used as a protein-vitamin-minerals supplement in poultry, calf (Joshi et al., 1983) or even human nutrition (Pirie, 1978; Shah, 1983). Deproteinised juice (DPJ) contains soluble components of the plant cell. It is considered as a by-product of GCF system. This fraction can be used along with PCR in animal nutrition (Joshi et al., 1983), for irrigation as a fertilizer source (Ream et al., 1983; Jadhav and Mungikar, 1998) or for growing useful microorganisms (Pirie, 1971, Pirie, 1978; Baviskar et al., 1999).

It is seldom possible to date precisely the beginning of this new line of research. Most of the work on GCF has been undertaken with the objective of extracting protein from green leaves for use in human food. Systematic studies on green vegetation as a source of protein nutrition began in the nineteen twenties (Osborne, 1924). Subsequently several workers designed, tested and described equipments for use in protein extraction from green leaves.

Heating of the juice released during fractionation has been widely recommended for the preparation of leaf protein concentrate. Pirie (1971) and Pirie (1978) developed various types of systems wherein the juice is coagulated by heat. Several types of machinery have been designed, tested and described by different workers for fractionation and LP extraction. During 1940, different types of hammer mills, screw expellers, sugarcane rolls, ball mills, rod mills, and dough-breakers were tried to extract protein from green leaves (Pirie, 1987).

The American concept of GCF in general and LP production in particular is different. They believe that only the excess proteins from foliages should be extracted, leaving behind the residue to produce partly dehydrated high grade animal feed with low moisture and moderate protein content. For this purpose, they suggest the use of sugarcane roll press for maceration of green crops and extraction of juice from them (Knuckles et al., 1970, Kohler and Bickoff, 1971). In some machinery, the processes of maceration and pressing are carried out simultaneously. In most cases they include a screw press (Casselman et al., 1965; Edwards et al., 1975).

A review of work done after 1970 on the topics of LP has been prepared by Central Food Technological Research Institute (CFTRI), Mysore; at the all India get-together held on 4-5 July, 1977. Summaries of work done in late seventies in Europe and the U.S.A. have also appeared (Kohler et al., 1977).

The contribution to our knowledge on leaf protein till today conclude that the nutritional value of LPC extracted from green foliages is comparable to that of protein isolates of animal origin and superior or similar to seed proteins (Morris, 1977).Fibrous pressed crop (PC) residue, left after the extraction of LP is suitable feed for cattle (Connell and Houseman, 1977). Economic advantages could be gained in agriculture with commercial production of LP (Wilkins et al., 1977). Farm based fractionation of green crops and utilization of PCR and LPC can be undertaken in rural areas without disturbing the prevalent agricultural, dairy and poultry practices (Joshi et al., 1983).

A review of Indian work on leaf protein has been given by Joshi (1983). In this review, he noted that despite of over three decades of research in this country, there is no regular production and use of leaf protein as either food or feed. He stressed the need of developing simple technology with an integrated approach for maximum utilization of LP and other fractionation products. It has been suggested that the LP project

should run in collaboration with the dairy development programmes, and small farm-based fractionation units in villages should produce feed grade pressed crop for the cattle and food grade leaf protein concentrate for non-ruminants.

Lucerne (*Medicago sativa* L.) is a highly productive crop with consistent performance. The crop yielded over 150 t fresh vegetation, 25 t dry matter, 6 t crude protein and 3.2 t extractable protein per hectare when harvested 14 to 16 times in a year. With liberal use of fertilizer N, hybrid Napier grass yielded 200 to 250 t fresh vegetation, 40 t dry matter, 6 t crude protein and 2 t extractable protein per hectare per year under irrigated condition. Cowpea is best adopted crop to the monsoon climate in this region. The rate of 11.2 kg/ha/day extracted protein from this crop during monsoon of 1970 is the highest ever recorded for a season so far in this laboratory (Deshmukh et al., 1974). Berseem, one of the best winter forage crop in north India, was cultivated in this region during 1971 to 1974 (Mungikar, 1974; Tekale, 1975). The crop yielded from 40 to 95 t green fodder in six cuttings. The yields of extracted leaf protein from by-product leaves of brassicas, radish, beet root and turnip ranged between 76 to 170 kg/ha (Giri and Nagpal, 1984). Cereal-legume intercropping showed yield advantages (Kasture and Mungikar, 1984).

Mungikar (1986) reviewed the work undertaken in department of Botany, Marathwada University, Aurangabad, India on various aspects of leaf protein. The contributions made so far by this Department indicated a great scope for initiating small scale fractionation units in this area for the production of food and feed grade products of high nutritive value at reasonable costs. DPJ is used in Microbial biotechnology (Sayyed and Mungikar, 2000).

Toxic constituents like nitrates and oxalates, accumulated in the foliages of several plant species, were generally removed in the DPJ and as a result of which the PC and LPC contained safer levels of these toxic elements in view of their value as either feed or food (Mungikar, 1974; Sayeed and Gogle, 2002).

Thiamine is present in practically all of the plant commonly used as food. The enrichment of flour, bread, corn and macaroni products with thiamine has increased considerably the availability of this vitamin in the diet. Since the vitamin B is water-soluble and some what heat- labile particularly in alkaline solutions. It may be lost in the cooking water. Thiamine deficiency affects predominantly the peripheral nervous system the gastrointestinal tract and the cardiovascular system. Thiamine has been shown to be more effective in the treatment of beriberi, alcoholic neuritis and the neuritis of pregnancy or of pellagra. If the vitamin is taken in excessive amount as may occur by the use of thiamine containing vitamin supplements the excess vitamin is promptly excreted in the urine.

Riboflavin B_2 widely distributed throughout the plants and animal kingdoms with very rich sources in anaerobic fermenting bacteria. Riboflavin is known to exist in various enzyme systems. The first riboflavin phosphate (riboflavin mononucleotide) is a constituent of the yellow enzyme. Characteristic tissues of the lips issues at the anales of the mouth (chellosis) localized seborrheic dermatitis of the face a particular type of glossitis (Magenta tongue) and certain functional and organic disorders of the eye may result from riboflavin deficiency. The relationship of blood levels of riboflavin to the amounts of the vitamin stored in the body remain to be elucidated. Urinary excretion of less than 50 µg riboflavin in 24 hours in usually associated with clinical signs of deficiency Harries et al. (1965). Riboflavin (formerly lactoflavin vitamin) constituent of tissue respiratory enzyme system as well as some enzyme (flavor protein) involved in amino acid and lipid metabolism.

It has been difficult to establish definitely the human requirement for vitamin by probably because the quantity needed is not large and because bacterial synthesis in the intestine provides a portion of that requirement. Vitamin B_6 is required by all animals investigated so for impaired growth result when immature animals are maintained on a vitamin B_6 free diet. Pyridoxine deficiency in humans may also be associated with a reversible hypo chromic microcytive anemia with a high serum iron similar to that observed in pyridoxine deficient animals. Vitamin B_6 is unquestionably required in the diet of humans although this vitamin is adequately supplied in the usual diets of adults children and all but very young infants.Pyridoxine essential to transulfaration and in conversion of tryptophan to niacin also as a coenzyme in transamination participants in metabolism of essential fatty acid, essential in synthesis of porphirins (eg. heme for hemoglobin and cytochromes)

It is of great interest that probably the only original source of vitamin B_{12} is microbial synthesis. Vitamin B_{12} has its greatest effect on nucleic acid formation. This by virtue of its action in cycling 5 methyl tetrahydrofolate back into the folate pool (Silber and Moldow, 1970). The most characteristic sign of a deficiency of vitamin B_{12} in man in the development of a macrocytic anemia or characteristic lesion of the nervous system. (Combined system disease) neurologic systems may supervane in B_{12} deficiency states without the prier development of anemia. Vitamin B_{12} involved in purine and pyrimidine metabolism synthesis of nucleic acid (DNA) mathration of red blood cells, methionine metabolism and transmethylation contains cobalt, which is the only known function for this element Ritche (1968).

The infant is usually well supplied with vitamin C at birth. However, infant 6-12 months of age who are fed processed milk formulas not supplemental with fruit and vegetable are very susceptible to the development of infantile scurvy. Vitamin C deficiency a syndrome termed "bachelor scurvy" ford faddist may also develop vitamin C deficiencies it their diet void raw food. Particularly fruit and vegetables. The best food sources of vitamin C are citrus fruits, berries, melons, tomatoes, raw cabbage and leafy green vegetables. The tissues and body fluids contain varying amount of vitamin C with the exception of muscle, the tissues of the highest metabolize activity (Witting, 1972). Sever ascorbic acid deficiency produces scurvy the pathologic signs of this deficiency are almost entirely confined to supporting tissue of mesonchymal origin (bone dentine, cartilage and connective tissue.) Vitamin C maintains normal intercellular material of cartilage, dentine and bone probably has specific role in collagen synthesis by activity on praline hydroxylation. Association with oxidation reduction system of tissues metabolism of some amine acids e.g. tyrosine praline (Suttic, 1973).

According to some clinical nutritionists folic acid deficiency is possible the most common vitamin deficiency in North America and Western Europe. This is especially true in pregnancy wherein folic acid deficient is said to be the most frequent cause of mesalublastic anemia. Folic acid deficiency should be considered in connection with alcoholism hemolytic anemia's tropical and nontropical sprue and the anemial occurring in infancy pregnancy or malignancies (Schwan, 1954). Folates are present in a wide variety of plant tissue Manly as poly glutamates in reduced methyl or fermyl forms. The monoglatamale pleroylmonoglutamic acid chemically designated folic acid (folacin) is actually a minor component of the folates contained in the diet. The concept of competitive inhibition or metabolic antagonism reveals that, the antagonists to folic acid have found clinical application in the treatment of malignant disease, and confirmation of the action of folic acid in cell growth has been obtained in studies of the effect of these antagonists on cells maintained in tissue culture. Folic acid involved in transfer and utilization of the single carbon moiety, participates in synthesis of purines, thymine and methyl groups has specific role in metabolism of histidine and well demonstrated role in hematophoresis (Silber and Moldow, 1970).

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