INTRODUCTION
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Protein-energy malnutrition (PEM) is one of the most outstanding problems affecting the humanity especially the infants and the young children. It not only contributes to increased infant mortality but also results in permanent physical and mental retardation.

Anaemia of varying severity is a common feature of different forms of PEM (Pereira and Baker, 1966; Adams et al, 1967; Viteri et al, 1968; Gupta et al, 1970a), but it is still not known whether it represents a pathologic (Adams, 1970) or an adaptive (Finch, 1975) phenomenon. Manchanda et al (1969) have shown that the incidence of anaemia is 100 per cent in marasmic children in India. The type of anaemia reported in human PEM has shown considerable variation. It has been described by various workers to be normocytic (Altmann and Murray, 1948; Gupta et al, 1970), hypochromic microcytic (Mehta and Gopalan, 1956; Adams and Scragg, 1965; Adams and Berridge, 1969; Manchanda et al, 1969; Sandstead et al, 1965b) or macrocytic (Altmann and Murray, 1948; Adams, 1954). Bone marrow has been found to be normoblastic, macro-normoblastic (Woodruff, 1955), megaloblastic
A universal finding in severe PEM is a reduction in the total serum proteins and since protein is a major component of haemoglobin it is reasonable to suspect decrease in haemoglobin synthesis (Cronje et al, 1961). It is believed that one of the causes of decreased haemoglobin synthesis in PEM is an abnormality in the synthesis of protoporphyrin and/or a defect in the iron transport.

Apart from proteins, iron and folic acid are the other two important haemopoietic factors. Iron deficiency has been thought to be responsible for some of the anaemias observed in severe PEM. Because of the existence of low serum iron levels and absence of iron in the bone marrow, peripheral blood shows hypochromia and microcytosis. It is supported by the observation
that iron therapy alleviates these symptoms. Decreased absorption of iron has been suggested as a reason for these findings (Mehta and Gopalan, 1956; Bosch et al, 1965; Pereira and Baker, 1966; Adams et al, 1967).

The well documented low serum folate and megaloblastosis which responds to folic acid in a variable number of children suffering from PEM, indicates, that under special circumstances, folic acid deficiency can also contribute to anaemia (MacIver and Beck, 1960; Ghitis et al, 1967) of PEM. This could be due to decreased intestinal absorption in the malnourished children since they have a variety of absorptive defects and chronic diarrhoea (Mattoth et al, 1964).

Other factors causing anaemia might be obscured by over all malnutrition in these children. The low concentration of vitamin E and the haematological response obtained on administration of large doses of vitamin E to malnourished patients suggests that vitamin E could also play a role in the pathogenesis of anaemia of PEM (Majaj et al, 1963; Majaj, 1966). Foy et al(1961) and Foy and Kondi (1966) suggested that riboflavin
deficiency associated with PEM could be responsible for
the erythroid aplastic crisis in Kwashiorkor. The fact
that these crises responded not only to riboflavin admi-
nistration but also to prednisone made them believe that
decreased corticoid activity in PEM could also be invoked
as a cause of anaemia.

Erythropoietic depression may be considered
still another possible cause of anaemia in PEM. This
can be explained on the basis of diminished erythropoietin
formation or retardation of protein synthesis in
erthyroid precursors due to less availability of proteins.
It has been observed that depression of erythropoiesis
is attributed to a diminished formation of erythropoietin
(Reissmann, 1964 a,b; Foy and Kondi, 1966; McKenzie et al,
1967). In experimental animals acute or chronic starvation
gives rise to moderate anaemia resulting from a reduced
output of erythropoietin which has been attributed to
lowered tissue oxygen needs (Reissmann, 1964 a,b).

The common occurrence of a rapid and marked
decrease in haemoglobin levels at the beginning of the
protein therapy, which cannot be fully explained by a rise in plasma volume, has suggested the possibility of a haemolytic component in anaemia of PEM. Early reports of increased serum bilirubin by Waterlow (1948) and Jaysekera et al (1951) suggested that there might be either increased red cell destruction or impaired liver function. Marvin and Audu (1964) and Zamar et al (1966) found decreased red cell survival in malnourished children. Lanzkowsky et al (1967) showed considerably reduced erythrocyte survival in patients with PEM. Brown et al (1978) confirmed the observations of Lanzkowsky et al (1967) regarding the shortened RBC survival in this syndrome. This shortened survival time appears to be due to both corpuscular and extra-corpuscular factors. The shortened RBC survival in PEM might result either from structural and/or functional changes in the cell membrane or due to defect in handling the oxidant stress by glutathione cascade.

Erythrocyte glutathione (GSH) levels have been shown to be increased in anaemia due to vitamin B₁₂ and/or iron-deficiency (Hopkins and Tudhope, 1973a).
It has been suggested that this may be in response to a fall in haemoglobin levels to protect the haemoglobin molecule from oxidative denaturation. GSH is regenerated by the reduction of its oxidized form by the action of the enzyme GSSG: NADPH reductase (GSSG-R), whose activity is also increased (Ramachandran and Iyer, 1974). GSH is oxidised to its disulphide form by the action of the enzyme GS\textsubscript{H}-peroxidase (GS\textsubscript{H}-Px) during peroxide-detoxification, but there is no correlation between the activity of this enzyme and the levels of GSH in anaemia (Hopkins and Tudhope, 1973 b). The activity of glucose-6-phosphate dehydrogenase (G\textsubscript{6}PD) is also important to erythrocytes as it provides the reducing equivalents (NADPH) to regenerate and maintain the tripeptide in the reduced form.

There are few isolated reports about some of the components of glutathione cascade in PEM. The erythrocyte GSH-Px have been found to be low (Verjee and Behal, 1976; Fondu et al, 1978 d) and same is true for G-6-PD and GSSG-R (Verjee and Behal, 1976) in this syndrome. There is no comprehensive study about this
system in anaemia of PEM. Thus the role of nutrition in modulating cellular antioxidant defense system deserves careful evaluation especially with reference to shortened RBC survival in anaemia of PEM.

**Objective of the Present Study:**

1. It is clear from above that so many factors contribute to the anaemia of PEM. Iron-deficiency is most wide spread in tropical and sub-tropical areas and is considered to be one of the important contributory factor in the pathogenesis of anaemia of PEM. However, the role of iron alone in anaemia of PEM has not been studied so far and such a study would be interesting. In order to evaluate its role in the pathogenesis of anaemia of PEM, it is planned to study the haematological characteristics and iron metabolism in children with PEM before and after two dietary regimens; one in which body iron deficit will be compensated along with a diet complete in all other haemopoietic factors and the second in which this deficit will not be replenished although
the diet used will be the same as in the first group.

2. As mentioned above, a comprehensive picture of cellular antioxidant defense system (glutathione cascade) for peroxide detoxification has not been worked out in anaemia of PEM. It is, therefore, considered worthwhile to study the various components of GSH metabolism in marasmic children. Moreover, the effect of two dietary regimens mentioned above will also be evaluated in relation to the components of glutathione system.