HAIR AS AN INDEX OF PROTEIN MALNUTRITION

Mendel Friedman* and R. Orraca-Tetteh**

*Western Regional Research Laboratory, U.S. Department of Agriculture, Berkeley, CA 94710
**Department of Nutrition and Food Science, University of Ghana, Legon, Ghana

ABSTRACT

Hair samples from seven sick Ghanaian children were analyzed for amino acids. Cystine was determined by a procedure of Friedman using tributylphosphine and 2-vinylpyridine to change residues of cystine (and cysteine, if present) to \( S-\beta-(2\text{-pyridylethyl})-L\text{-cysteine (2-PEC)} \). This acid-stable derivative is released by normal acid hydrolysis and is eluted as a well-resolved peak before lysine in conventional ion-exchange amino acid analysis. The average cystine content of six children suffering from kwashiorkor or marasmic kwashiorkor was found to be about 20% less than that of the one remaining child, whose protein nutrition was judged adequate. In view of conflicting evidence of the relation of hair cystine content and nutrition, we believe further definitive studies of this subject are urgent. No other substantial difference in amino acid composition was noted.

INTRODUCTION

More than five hundred million people are estimated to be malnourished, with about fifteen thousand daily deaths attributed to malnutrition (NRC, 1975). At the same time, no accepted simple technique is currently available that permits rapid, large-scale assessment of protein nutritional status (Hartman et al., 1966). An attractive possibility is that the nutritional status of individuals can be established by analysis of hair because it is synthesized at a rate about four times as fast as any other tissue proteins (Sims, 1968; 1970). Since hair is all protein, intake of dietary protein that is quantitatively insufficient or lacking in
specific essential amino acids would be expected to affect its growth, composition and physical properties. Various studies of composition changes have not always given conclusive results (Bigwood and Robazza, 1965; Hartman et al., 1966; Lightbody and Lewis, 1929; Koyanagi and Takanohshi, 1961; Koyanagi et al., 1965; Menkart et al., 1966; Morel et al., 1966; Ogura et al., 1962; Platt and Nagchauthuri, 1954; Pollitt and Stoner, 1971; Narasinga, and Gopalan, 1957; Robbins and Kelly, 1970; Sanda, 1966; Sanda and Bradfield, 1967; Sims, 1970; Sinclair, 1957; Smuts et al., 1932; Wysocki et al., 1954). Extensive efforts have been made to devise simple and convenient methods to diagnose malnutrition from other hair properties (Bradfield, 1968, 1973a, 1973b, 1974; Burley, 1960; Burley and Horden, 1960; Crounse and Fraser, 1969a, 1969, Fraser et al., 1972; Gillespie, 1967; Gillespie et al., 1969; Johnson et al., 1976; Latham, 1966; Kutner et al., 1973; Hartman et al., 1966; Lee and Luttrell, 1965; Malcolm et al., 1973; Menkart et al., 1966; MacDonald and Warren, 1961; Sims, 1967, 1968; Tanphaichitr et al., 1977; Vandiverie et al., 1971; Whitley et al., 1970; Wilson et al., 1971; Wolfram et al., 1970; Zain et al., 1977) and other biochemical criteria (Bodwell, 1975; Gopalan et al., 1963; Gopalan and Srikantia, 1973; Gurson, 1966; Ingenbleek et al., 1975; Kahawati and McLaren, 1970; Nammacher et al., 1972; Nhuga, 1977; Olson, 1975; Waterlow, 1972; Waterlow and Alleyne, 1971).

None of the proposed methods seems adequate. Thus, Hartman et al. (1966) point out that estimating nutritional status of large population groups is difficult in the absence of a single direct indicator of protein nutrient. They note that although protein nutritional status may be inferred from several nonspecific indices such as total serum protein, serum albumin, hemoglobin, stature, weight, hair pigmentation etc., such multiple observations may be uncertain because they are influenced by many unrelated factors. For further evidence, we have evaluated hair samples from children suffering from kwashiororkor and related diseases associated with malnutrition. Several publications (see below) suggest that the content of the amino acid cystine of hair may respond to the nutritional status of the child, although the evidence is by no means consistent. Discrepancies in the reported relationships of cystine levels in hair of normal and malnourished subjects could be due, in part, to problems and inaccuracies in cystine analysis. Direct assay of cystine in protein hydrolysates by ion-exchange chromatography normally gives low and varying values, because L-cystine is partly destroyed during acid hydrolysis. Consequently, many attempts have been made to change cystine residues quantitatively to acid-stable derivatives that are resolvable in standard amino acid analysis (Friedman, 1973). Derivatives tried for this purpose include, among others, cysteic acid, S-sulfocysteine, S-carboxymethylcysteine, and S-carboxymethylcysteine. Most of these, however, are