precise molecular configuration may not be known and whose inclusion would remove the diet from the chemically-defined-diet category, include, for example, proteins, peptones, starches, dextrins and fats. On the other hand, nutrients whose molecular configurations are precisely known and may be a part of chemically defined diets include, for example, amino acids and their simple precursors, such as purified peptides, mono- and disaccharides and esters of pure fatty acids.

Various attempts have been made to formulate synthetic diets for human consumption to supply all of the requirements of the essential amino acids and nitrogen needed for growth and sustenance or normal physiological activity. In the formulation of such synthetic diets, the principle which has been employed was to substitute for proteins in the natural foodstuffs with their constituent amino acids. However, attempts to formulate amino acid mixtures that would be nutritionally adequate and at the same time palatable for human consumption have heretofore been unsuccessful. Although nutritionally adequate amino acid mixtures containing in addition carbohydrates, fats, minerals, and vitamins have been formulated and have been successfully employed in metabolic and nutritional studies with experimental animals and with humans, long term provisions of defined diets to humans has been thwarted by virtue of the unpalatable nature of the diets. Amino acid mixtures in such defined diets have been provided, in essence, in two forms, either as mixtures of individual crystalline amino acids or as mixtures of amino acids obtained through the hydrolysis of proteins. Although such mixtures can be taken by humans, the taste of such mixtures has heretofore been such as to make them objectionable to those who are consuming them.

Adequate chemically defined diets have also been formulated, and one such diet is described in Nature, volume 205, No. 4973, pp. 741–743 (Feb. 20, 1965). This diet has also been unpalatable to humans, and its usefulness has generally been limited to experimental projects where the desire of the subjects, as in the furtherance of research, overcame the problem of unpalatability.

From a commercial and a research viewpoint, it becomes desirable to develop palatable amino acid mixtures which will not impart an off-taste and off-odor into nutrient mixtures containing other essentials.

It is an object of the invention to provide a palatable food composition for human consumption containing all of the essential amino acids. It is another object to provide palatable mixtures of amino acids and other nutrients which will satisfy the essential amino acid requirements in diet formulations for human consumption. A further object is to provide such amino acid-containing diet formulations which have good storage stability in aqueous solution and in the solid state. These and other objects of the invention will be apparent from the following detailed description of various embodiments having certain features of the invention.

It is believed that the objectionable taste of previous chemically defined diet formulations has three basic or major causes: namely, (a) the inclusion in the formulation of amino acids or substantially simple amino acid derivatives containing sulfhydryl (SH) groups (e.g., cysteine, homocysteine) or other groups which are convertible to sulfhydryl groups (e.g., cystine, homocystine); (b) the inclusion in the formulation of amino acids or substantially simple amino acid derivatives whose taste is incompatible with the flavor of the mixture of the other ingredients (e.g., glutamic acid or its alkali metal salts, such as sodium glutamate); and (c) the use of amino acids or substantially simple amino acid derivatives that are not of sufficient purity. Derivatives are considered to be products which evolve by decomposition of the amino acids or by chemical conversion of amino acids to other discrete chemical entities.

The off-taste caused by the sulfhydryl group of amino acids or simple amino acid precursors is avoided when the concentration of such amino acids which contain the sulfhydryl group, or which contain groups that are convertible to the sulfhydryl group, is limited in the food composition. Generally, the amino acids will be consumed as a water solution together with a carbohydrate, such as glucose, and various essential minerals, and it has been found that the amount of sulfhydryl group which can be tolerated is not an absolute figure but is dependent upon the pH of the solution. A food product of this general type having a fairly high carbohydrate content would normally have a pH within the range of about 3 to about 7.5, and for flavor purposes, the pH of the food composition is preferably maintained between about 3.4 and about 5.7. To assure palatability in such a solution having a pH of about 5.7 or greater, sulfhydryl groups should not be present in an amount greater than about 0.05 gram per liter, based upon the weight of the sulfhydryl groups alone. However, it has been found that the palatability of such a solution at a lower pH is even more sensitive to the amount of sulfhydryl groups present and that when the pH of the solution is about 3.7, the tolerable concentration of sulfhydryl groups is reduced to a value of 0.038 gram per liter. In the middle of the pH range, the change in the tolerance level of sulfhydryl groups is generally directly proportional to the change in pH, with the tolerance for sulfhydryl groups decreasing about 0.003 gm./liter for each decrease of about 0.5 in pH.

The amino acids for the composition can be provided either as the free amino acids or as suitable simple precursors thereof (for example, purified peptones and peptides) which will be converted to free amino acids by the metabolic processes of the human body, or as mixtures of the aforementioned groups. Moreover, as used in this application, the term "amino acid" or "free amino acid" or the named amino acid should be understood to also include the simple reaction product of the amino acid and another chemical compound (for example, esters, amides and salts of amino acids) in which form the amino acids may also be employed without detracting from their nutritional utilization.

Palatable amino acid mixtures for human consumption can be formulated and used in a complete diet with carbohydrates, fats, vitamins and minerals, which mixtures may be either substantially pure amino acids or may be amino acids in the form of protein hydrolysates, such as might be obtained from the hydrolysis of casein. As indicated above, one of the keys to obtaining a palatable formulation lies in limiting the amount of the sulfhydryl (SH) groups and/or the disulfide linkages in the amino acid components in the formulation. If the critical limits are exceeded, the resulting product has a high degree of objectionable sulfurous taste and is for all practical purposes unpalatable and unacceptable for human consumption. It is to be noted that taste is inherently susceptible of subjective definition, and for purposes of the present application, a product is considered unpalatable if it is rejected by at least about 75 percent of the persons who taste it. Moreover, if a composition should exceed the aforementioned critical level upon initial formulation, the taste worsens upon storage for any appreciable length of time, becoming completely obnoxious to taste and smell.

Of the amino acids derived from proteins with which the present application is concerned, those containing sulfur are cysteine, cystine and methionine. Methionine is the only essential amino acid of the three and can give rise to the creation of methyl mercaptan, which is treated separately hereinafter. Although cystine and cysteine are so called nonessential amino acids, either can be substituted for part of the required amount of methionine. In the case of nutrient compositions that are formulated from substantially pure amino acids, the amount of SH groups and disulfide linkages (which form SH groups upon reduction in solution by other components, such as ascorbic acid) in