Hydrolyzed and Autolyzed Vegetable Proteins as Functional Food Ingredients

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ABSTRACT

Hydrolyzed vegetable or plant protein (H.V.P. or H.P.P.) can be defined as mixtures containing amino acids and frequently other substances such as salt and peptides, obtained by hydrolysis of vegetable proteins. On an industrial scale two types of hydrolytic processes are applied: acid and enzymic hydrolysis. HVP estimated sales in the western world are at least $100 million. Most HVPs are produced for internal use by soup manufacturers, for use as vital meaty or savory flavoring ingredients in bouillons, soups, sauces, processed meat, fish and poultry products and snacks. Other HVPs are more ready-made products, or have obtained additional meat flavor value by careful blending and/or by processes based on Maillard-type reactions. Of substantially less importance is the use of HVP as whipping, foaming or areating agent, as nutritional ingredients or as bread or baking improver. Most of the HVPs used for these purposes are only partially hydrolyzed by enzymes or by alkaline treatment. The legal status of HVP, food ingredient or food additive, and its safety was discussed recently at various locations. So far these discussions have resulted in the tentative conclusions that HVPs are food ingredients which need standardization, and which, at their presently used levels, can be considered as being GRAS.

HISTORY

Hydrolyzed proteins as food or food ingredients originated in East Asia, in countries like Japan, China and Indonesia, where for many centuries fermentation processes have been used for preservation and/or modification of the taste of protein containing primary foods such as fish and meat. Also, vegetables like pulses, corn, soybeans and wheat were used as raw materials for similar fermentation processes. The well known soy sauce, for instance, is prepared by the digestion of a 1:1 mixture of soy grits and wheat with the proteolytic and amylolytic enzymes from the mold *Aspergillus soyae.*

In the search for speeding up the soy sauce production process which could take as many as two or even three years, the Japanese industry started in the beginning of this century with the introduction of certain chemical treatments, e.g., acid hydrolysis. Besides as flavor booster for traditionally fermented soy sauce, soybean hydrolyzates were and are still being used, together with ingredients like salt, caramel and corn syrup, for the production of a cheap soy sauce.

The industrial interest in hydrolyzed vegetable proteins (HVP) grew sharply after Ikeda's discovery in 1908 of monosodium glutamate (MSG) as the major flavoring compound in HVPs.

They were found by Ikeda to be relatively rich and cheap sources for the isolation of MSG, and this know-how was the start for its commercial production by Ajinomoto.

In Europe industrial production of HVPs was pioneered, already in 1886, by Maggi in Switzerland. The first commercial product based on HVP was meant as an alternative for Liebig's meat extract.

As a product in its own right, this HVP soon became a very popular liquid seasoning under the trade name Maggi. Mixed with fats, salt, and frequently also with meat extract, HVP also proved to be a commercial success in bouillon cubes.

In the USA the industrial production of HVPs as sources for MSG and probably also as flavoring ingredients for fabricated foods, started only a few years before World War II.

DEFINITIONS, RAW MATERIALS, PROCESSES, AND ECONOMY

Before discussing some functional properties of HVPs, I want to define them and to report some general data about them. Hydrolyzed vegetable or plant proteins (HVP or HPP) are defined as mixtures composed primarily of amino acids and frequently other substances such as salt and peptides, which are obtained by hydrolysis of vegetable proteins. Autolyzed vegetable proteins are obtained through the breakdown of yeast cells by their natural catabolic enzymes. Since yeasts are botanically classified among the lower plants, and because half of their dry matter consists of proteins, yeast autolyzates can be classified as a special type of HVP.

The most common sources of vegetable protein for HVP production are defatted oil seeds such as soy and groundnut, gluten from cereals such as corn, wheat, rice, yeasts and algae. Unrefined, defatted meal of soy and groundnut contains ca. 50% protein, but via extraction and/or precipitation processes this can be increased to 80%. Cereal glutens are usually obtained in wet milling processes and contain 60-70% protein.

On industrial scale, mainly three types of hydrolytic processes are applied: acid, and enzymic hydrolyses, and autolysis. Hydrocholoric acid is the most commonly used acid, which easily leads to a 100% completion of the hydrolysis.

Hydrolysis by isolated proteolytic enzymes proceeds substantially slower and results in only partial hydrolysis. This gives enzymatically produced HVPs their unique physical propterties.

Yeast extracts are obtained by autolysis of yeasts, which are either primarily selected and grown for autolysis, or are obtained as by-products in the brewing or related industries. The autolysis or self-destruction of these yeasts on industrial scale is catalyzed by high temperature and/or a high salt concentration. Besides proteolytic, amylolytic and nucleolytic enzymes, many other enzymes are or can be active during the autolysis, and therefore this process needs careful control.

The economic importance of HVP as a food ingredient is illustrated by production volume, which in the western world alone can be estimated at 55,000 metric tons, worth more than $100 mln. More than half of this volume is

produced in Europe, and a substantial part of it is produced for captive use by internationally well known bouillon cube and/or soup manufacturers.

FUNCTIONAL PROPERTIES OF HVPS

As already mentioned, HVPs find their major applications in bouillons, soups, soy sauce, and similar condiments. They are used because of their meaty or savory flavor and/or their flavor-enhancing properties. For the same reasons, they are also used in sauces, gravies, meals, in processed meat, fish and poultry products, and in snacks.

Recently it has been calculated that in the USA the average application percentage in 70 fabricated foods amounts to 0.6%, calculated in the product ready for consumption. Depending on the type of product, this percentage can vary from 0.2% up to 1.3%.

Altough being not well defined in terms of composition and flavoring properties, the greater part can be considered as commodity products. Other HVPs are more tailor-made products obtained in careful refining or blending processes, or have obtained additional flavor value by processes based on Maillard-type reactions.

Of substantially less economic importance is the use of particular HVPs as whipping, foaming or aerating agents in, e.g., ice creams, puddings, confectionery products, or as bread or baking improver. The greater part of the HVPs used for these purposes is only partially hydrolyzed by enzymes or by acid or alkaline treatment. In particular the partial and selective hydrolysis by proteolytic enzymes offers great opportunities in the modification of the functional physical properties of proteins. Besides the properties already mentioned, the solubility around the isoelectric pH can be influence, as well as the gelling properties, the water-binding capacity, the emulsification capacity and the taste (bitterness !).

Nutritional values in certain medical foods, in canned vegetables and in citrus juices used as combined coloring and flavoring ingredient in beer and coffee, and the potency of HVP to be applied as antioxidant should be mentioned.

Returning to the most important reason for the use of HVPs in foods, their flavoring properties, more in particular their meaty or meatlike flavor, it is most interesting to compare the flavor compositions of meat and HVP, and to notice the similarities and differences. Thus, indications can be obtained for possible improvements in the flavoring properties of HVPs.

Fresh cut meat needs first a proper conditioning (aging), during which enzymic (hydrolytic) processes liberate flavor precursors, from which during the subsequent cooking or frying meat flavor compounds are formed, mainly in nonenzymic browning reactions. On the other hand, during the preparation of HVP, either enzymatically or by acid hydrolysis, the proteins are converted into peptides and amino aicds, whereas the macromolecular carbohydrates are converted into sugars, which degrade to a large extent further into products like hydroxymethylfurfural and levulenic acid.

Under the conditions of HVP production, or during the concentration of drying steps, part of the amino acids, sugars or sugar degradation products are converted, in nonenzymic browning reactions, Strecker degradations or oxidation and condensation reactions into the same or similar flavor compounds which are obtained during the processing or domestic treatment of meat: aldehydes, ketones, acids, (unsaturated) lactones, phenols, furans, pyrazines. Representatives from all these categories of organic compounds have also been found during the flavor analyses of soy sauce. However, in processed meat and probably also in soy sauce flavor concentrates, but not in HVP, sulfur-containing compounds like sulfides are also present.

Therefore, it is not completely unexpected that processing HVP with sulfur-containing compounds like cysteine and thiamine, or even with onion powder or with inorganic sulfides, improves the meatiness of its flavor. To some extent the same can be said with regard to the addition of sugars, because HVPs as compared with meat juices, are low in free sugars. The technology of these processes is described in many patents.

HVPs obtained by acid hydrolysis are also low in some nonvolatile acids, which have been found to be important taste compounds (as salts, of course) in meat extracts and soy sauce. Lactic, phosphoric, and succinic acid are typical examples. The HVPs furthermore lack any taste active nucleotides, but on the other hand, are relatively rich in glutamic acid. However, the high MSG content of some HVPs is one of the major reasons why in these days their legal position is under discussion; it also very recently has lead the suppliers to a voluntary limitation of the glutamic acid content of HVPs to a maximum of 20%.

I will finish my comparison of the flavor compositions of HVPs, soy sauce, and meat extracts with the statement that in the not too far future, flavorists will be able to reproduce the flavors of HVPs in cocktails of well defined flavor compounds. Whether such flavor cocktails also will be commercially applied will depend on the future legal status of HVPs.

LEGAL STATUS OF HVP

The legal position of HVPs recently has been discussed very thoroughly by various Codex Committees, on governmental levels both in Europe and the USA, and by the industry, both suppliers and users (joined in the I.H.P.C., the International Hydrolyzed Protein Council).

At its 12th session in Rome in April of this year, the Codex Alimentarius Commission has decided that HVPs should be considered as foods or food ingredients and not as food additives.

After the public hearing on hydrolyzed proteins in the USA in July of last year, the Select Committee On GRAS Substances (SCOGS) wrote a final report which concludes that there is no evidence in the available information that HVPs, applied as flavoring agents at their current levels, demonstrate a hazard to the public. The SCOGS furthermore concludes that, because of some uncertainties, additional studies should be made to prove the total safety of HVPs in food products.

In the meantime it is recommended that HVPs, including enzymatically hydrolyzed proteins and yeast autolyzates, should get an interim food additive status. For soy sauce applied at their current levels, a GRAS status can be given.

The Committee also has concluded that there is insufficient evidence to determine that reported adverse effects (lesions in the central nervous system) are not deleterious to infants when HVPs are added as flavoring agents to fabricated infant or junior foods. Anticipating this conclusion, the industry had already decided earlier to abandon the use of HVP as flavor agent in these foods.