Some Aspects of Research in the Application of Soy Proteins in Foods[1]

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ABSTRACT

Some of the work on soy products being conducted at Unilever Laboratories is described. Two off-flavor precursors and several meat flavors have been identified. By studying protein solubility relationships, a new method of concentrating soy proteins has been developed.

INTRODUCTION

This session is devoted to the commercial soy process and soy products. Soy proteins for human consumption are being used in increasing quantities. You might be interested in hearing the views of Unilever, a company involved in selling a wide range of food products in many countries. Do we encourage the application of soy products or do we avoid it? Are we taking an active part in it?

HISTORY

Those of you who have been working in the area will know that in the early fifties we patented the so-called chewy gel process. In this process, soy protein suspensions were extruded through a macaroni-type extruder. We never actually used this invention, however, because there was not sufficient commercial interest. Several years later Unilever research became actively engaged in the development of new protein products based primarily on groundnut protein. Again, no products were marketed; there was still no interest in them at the time. In the years before and after these ventures we followed developments closely, and looked at—and tested—various products on the market. Two years ago we started research again. Why did we do this and what have we done so far?

WHY VEGETABLE PROTEINS?

Following rapid improvements in the technology of soy processing and in the quality of the final product, Unilever became steadily more interested in soy products. We really felt that something important was going to happen in the area. But again and again we were confronted with deficiencies in the material which was commercially available and in our knowledge of how to utilize it.

In the meantime, meat prices have increased considerably. After study of the animal feed market, we anticipated a shortage of protein-rich feeds in the future. We feel that the availability of soy products will not keep pace with the increasing demand for animal feed. Meat prices, therefore, are likely to continue to rise and production must level off in the not-too-distant future. With the increasing world population and the continuing upward

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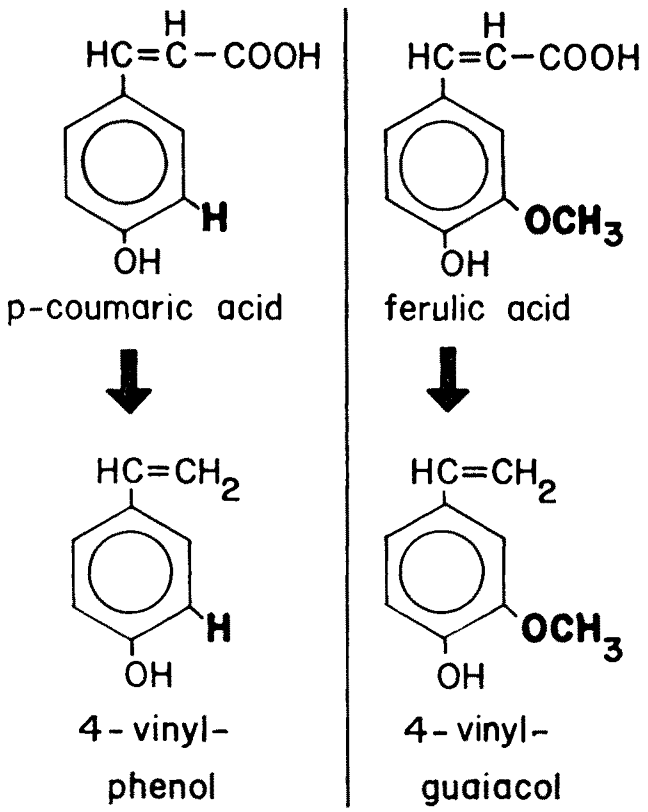

FIG. 1. Precursors of off-flavors.

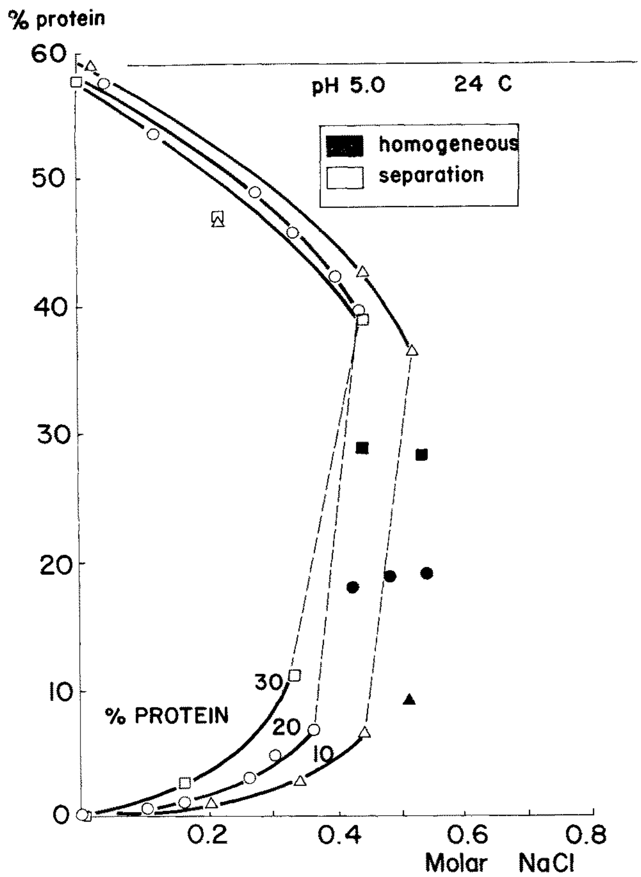

FIG. 2. Phase separation in the system soy protein:salt:water.

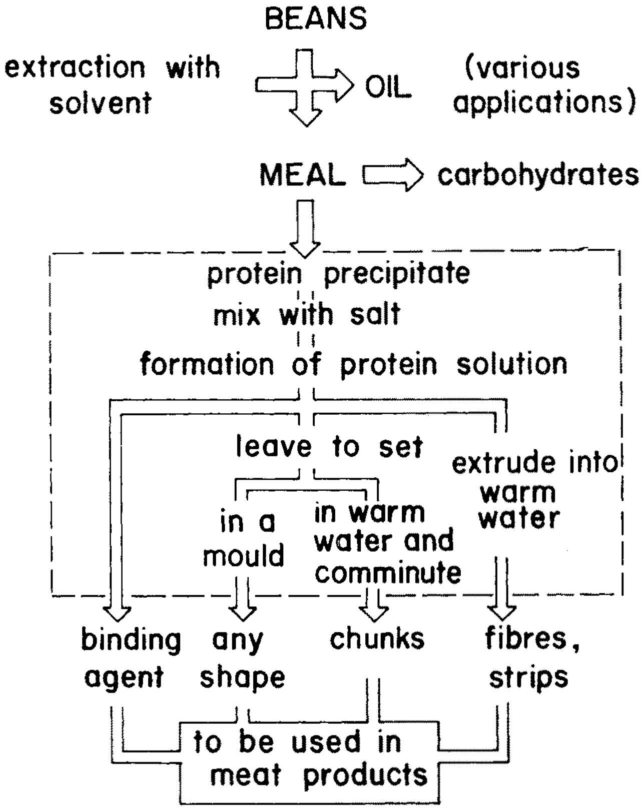

FIG. 3. Preparation of protein from soybeans.

trend in meat consumption, the application of vegetable proteins for direct human consumption will help protect our supply of proteins.

To produce 1 kg animal protein, we need ca. 10 k vegetable protein. This means that, if only 1% vegetable protein were used directly to human consumption instead of for the production of animal protein, our edible protein supply would be increased by 9%. This matches the annual increase in meat consumption which cannot continue indefinitely. We may conclude that an annual increase of 1% in the substitution of meat protein by vegetable protein would enable us to meet the increasing protein demand.

Another reason for the interest in new fabricated foods based on vegetable proteins is their inherent flexibility in composition. We will need these products if we want to keep pace with new developments in nutrition. We will want to be able to sell products free from cholesterol, products with polyunsaturated fat, products with restricted caloric values, or products with other nutritional criteria of which we are yet unaware.

All these arguments are not new to you. But why has Unilever entered the field of vegetable proteins again when so many excellent companies are active in this field. Simply because we felt there was something we could contribute. Prices of the better products available so far are too high to be competitive and the quality of the cheaper ones is too poor for them to be able to make an impact on the market.

WHY SOY PROTEINS?

We have chosen soy protein because we know more about it than about any of the other available protein sources. The fact that soy proteins have been eaten for generations in the Orient and also have been used for years in most western countries was felt to be another advantage. However, there is no reason to exclude any of the other raw protein materials as potential protein foods.

WHAT ARE UNILEVER'S CONTRIBUTIONS?

One of the most unpleasant characteristics of defatted soy meal is the off-flavor that develops when it is heated, the so-called cooked soybean off-flavor. The more you smell it, the more repelling it gets. Even the most enthusiastic taste panels soon gave up the task of evaluating potential raw materials and processes organoleptically. We had an idea that the compounds responsible for the cooked off-flavor were formed from natural precursors in the soy meal during the heating process. We, therefore, set ourselves the task of identifying the off-flavor compounds and their precursors.

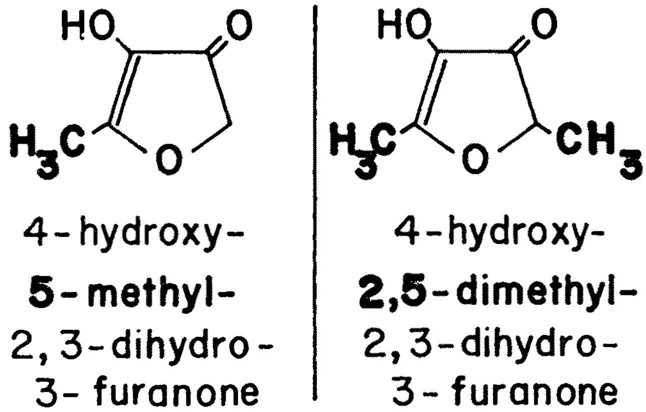

FIG. 4. Flavor compounds from beef broth.

Two compounds that could be identified as the main contributors to the cooked off-flavor were 4-vinyl phenol and 4-vinyl guaiacol. We found that the corresponding cinnamic acids were the precursors which decarboxylate upon heating as shown in Figure 1. Both precursors can be extracted from soy meal with polar solvents. The extracted soymeal does not produce the off-flavor when it is heated. We now can control the raw materials to prevent off-flavor formation.

Another development within Unilever stems from a closer study of the soy proteins and their solubilities. It is well known that soy proteins are scarcely soluble in water at their isoelectric point, but that they dissolve in dilute salt solutions. A more detailed analysis of the three-component system soy protein:salt:water showed for the first time that heavily concentrated protein solutions can be obtained.

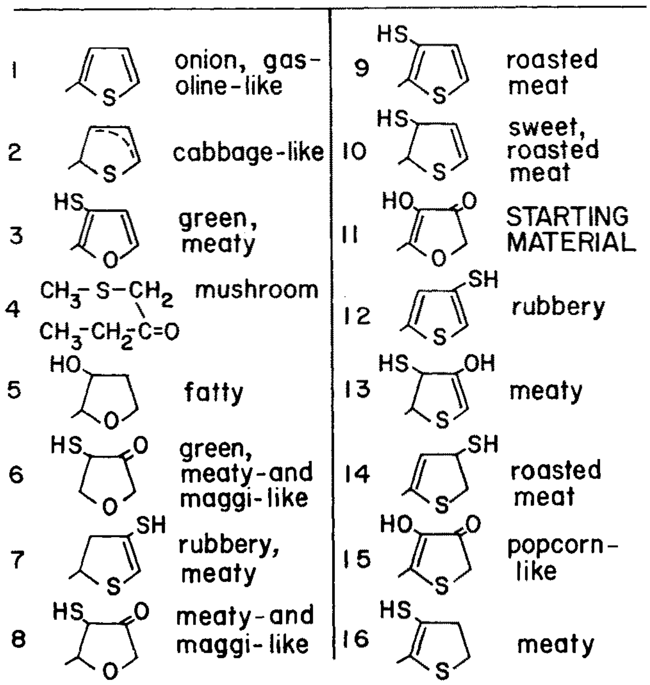

FIG. 5. Structure and odor of gas chromatographic components.

Figure 2 shows the phase diagram for the system soy protein:water:sodium chloride at pH 5. At a salt molarity above 0.5, all combinations yield a homogeneous liquid phase, but below 0.45 phase separation occurs giving a protein-poor layer and a protein-rich layer. The lower part of the diagram shows the classical solubility curves, but what interests us most is the protein-rich liquid phase.

We have used this knowledge to develop new processing techniques for creating fabricated protein structures as shown in Figure 3. The soy protein no longer has to be dissolved at high pH. Hence, loss of lysine, which can occur under such circumstances, is avoided. Thus, there are technological and nutritional advantages in this process. Although very nice products have been made in this way, we have not yet made the artificial beefsteak.

Despite the reduction of off-flavor and the introduction of texture, there is yet another factor limiting the application of soy protein—the difficulty involved in giving it a good positive flavor. We started meat flavor research in the early sixties when we patented the reaction between cysteine and other amino acids with sugar. On analyzing beef broth a few years later, we isolated and identified several attractive flavor compounds (Fig. 4). With all the other known compounds, they created a pleasant beef-like impression, but some of the more sulphurous flavors were still missing. When we analyzed real beef flavors by gas chromatography, we could smell these sulphurous flavor notes but we could not isolate and identify them. When we let the furanones react with cysteine, however, we got the real stuff—beef flavor mixtures with the right flavor notes. We have analyzed the mixtures and identified a range of components. Some of the compounds we identified are shown in Figure 5. Many of them have an interesting flavor. With additional experimentation, we were able to produce a range of flavors to make our fabricated vegetable products smell like meat. Nevertheless, we are still not marketing any of these soy products, mainly because of the legal constraints in many countries.

We feel, like many governments, that when you replace a product by another one the consumer may expect the same nutritional value as the imitation or substitution product. Government rules, laws, and standards are necessary. Of course, a government cannot accept any new development as ready for application overnight. What we hope is that the implications of the protein shortage will be realized and this will enable vegetable proteins to find their place on our tables.

Fortification with amino acids, vitamins, and minerals would enable the industry to make products of the same nutritional value as meat. It would even enable them to do better: fat intake could be reduced or, still more important, saturated fat could be replaced by polyunsaturated fat. Cholesterol would be absent and the caloric value lower than that of real meat. In this way, not only can we help solve the meat shortage in the developed countries and the protein shortage in the developing countries, but we can also improve the nutritional impact of an important part of our daily menu.