Functional Properties of Oilseed Proteins

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Abstract

The functional and physical properties, rather than the nutritional value, of protein in protein-containing products will largely determine their acceptability as ingredients in prepared foods. The nature of the protein per se, the presence of other constituents naturally present in protein-containing products, the degree to which the protein product is refined, the presence of other ingredients in a food system to which protein products are added, manufacturing conditions and a number of other factors, working singly or together, will influence the way proteins (as well as other ingredients) exert their functional characteristics. Differences in these characteristics are presented with examples of the manner in which various factors can influence functionality. Non-functional properties may be of interest for certain applications.

Introduction

Sufficient information is available to formulate a food composition which contains the required amounts of known nutrients, including vitamins, minerals, proteins, fats and carbohydrates, in proper balance to supply calories and chemical components which are required by humans at various stages of growth and under varying conditions of health. This can be done by combining any number of plant and animal products with synthetic chemicals to come up with a tremendous variety of combinations. The big problem is to produce such products which will be acceptable to the consumer as to flavor and mouth feel.

In compounding foods, the ingredients must have properties which will make possible the incorporation of such ingredients into a formulation so that when they are processed, the final product will have characteristics which will be acceptable to a consumer. The combination of ingredients must also have certain physical properties not only to permit proper handling and machining but to give efficient manufacturing.

With the increasing concern for improving protein quality and increasing protein content of many existing foods, and with rising prices of conventional protein-containing foods, there is interest in relatively low cost, high protein products which might be used to simulate existing foods, as additives to existing foods to produce acceptable food products at lower cost, or to formulate entirely new types of foods. To accomplish these ends, it is necessary that the protein materials have certain functional characteristics. In using the term functional we are referring to a property of an ingredient which may be desirable or undesirable when an ingredient is used in a food system. Usually an ingredient will have more than one functional characteristic. The physical form of an ingredient or its specific components may influence its functional properties and the physical characteristics of a processed food item. When a new ingredient is added to a standard food product and compared with the standardized product, there may be a difference in appearance, texture and flavor between the two products, which may make the product with the added ingredient more or less desirable than the original.

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Following are some ingredient characteristics which might be desirable and which may be referred to as non-functional (1): no undesirable change in water absorption, mouth feel, physical characteristics, appearance, flavor, color, odor or nutritional value. One could not expect to have all of these non-functional properties in any single additive. Water absorption may be decreased by heat or chemical treatment of protein materials, but it can never be completely eliminated. Isoelectric protein or protein salts of low solubility, such as soy calcium proteinate, would be products where water absorption would be decreased. How these products react in a formula will depend on the pH, temperature, the amount of water in a given system and the time factor or moisture ingredient contact. Mouth feel is largely determined by particle size and the ability of the additive to soften in the presence of moisture. The appearance of food is related to color, texture and shape. A non-functional ingredient should preferably not alter these characteristics unless its addition results in a more desirable finished food.

Discussion

There are a number of functional characteristics desired in protein-containing products. The importance of any one characteristic is dependent upon the particular use of the ingredient. Following are characteristics desired in functional ingredients: easy wettability, good water dispersibility with no settling, clear dispersions over a wide pH range, desirable viscosity characteristics, possible reactions or synergistic effects with other colloids to obtain desired viscosity, gel formation, water holding, controlled water absorption rates, emulsifying, stabilizing, thickening, dough forming, elasticity, film forming, adhesion, cohesion, aeration properties, low or compatible flavor. Enzyme activity of an ingredient may sometimes be of importance. More than one of these characteristics may be important in different phases of the processing of a food.

While there are a number of laboratory tests and analytical procedures which may give some useful information as to the physical and chemical nature of protein-containing ingredients, the only real way to tell how an ingredient will function in a food system is to incorporate that ingredient into a food formulation and produce the finished product.

The greater amount of work on functional properties of oilseed proteins has been done on soy protein-containing products, with a lesser amount on cottonseed, peanut, sesame, etc. Much of this work has been done on how to use these materials as a replacement for milk protein-containing products or to find new uses for the soy protein-containing products. While there is not much question that there will be some differences in functional characteristics in protein products from various oilseed sources, there is also no question that there will be many similarities.

In the past the major interest in oilseeds has been to obtain oil for edible purposes with the meal being used primarily for animal feeding purposes, but the concern for obtaining oilseed protein products for edible purposes has been increasing. Soy products have been used for edible purposes for thousands of years, but most of this usage has been limited to the production of certain types of edible products in the Orient. During the past 30 years or so, there has been an increasing interest in and use of soy protein-containing products for edible use which is different from the traditional Oriental foods. While the percentage of soy protein products used in food is relatively small in comparison to total production of soybeans in the United States, the total tonnage of soybeans used for food, specialty animal feed, government programs and industrial products presently represents a quantity in the range of 500,000 tons or around 16 million bushels per year on a bean basis.

The lowest cost products are soy flour and grits, which typically contain about 52% protein, less than 1% fat, 2.5% fiber, 8.0% moisture, 6.0% ash and 16.0% available carbohydrates. These analytical figures will vary depending on the equipment used in processing, processing conditions and year-to-year differences in soybeans. These products contain varying amounts of other constituents such as vitamins, color components, flavor components and many other components which may or may not be water dispersible.

With the soy flour and grits as starting material (Table I), one may produce soy protein concentrates by several possible procedures. Basically the process for producing soy protein concentrates consists of an extraction which removes most of the water soluble carbohydrates and other water soluble constituents resulting in a product which, on a dry basis, will be higher in protein and fiber, but usually slightly lower in ash and, depending on the process, either slightly higher or lower in fat than soy flour. The composition of the protein components in a soy protein concentrate may be essentially the same as in soy flour and grit products or may be considerably modified, depending on the process used to produce the concentrate.

With an isolated soy protein, the finished product is essentially free of the water soluble constituents and fiber components. However, there will be ash naturally associated with the protein or as a result of neutralization of the protein during the manufacturing process.

While it is generally considered that the protein portion of soy protein-containing products is the component most responsible for the so-called functional value of the soy products, the presence of salts and the fibrous portion may also have influence, with the fibrous portion frequently being detrimental, except where one may wish to have a product with high water absorption characteristics or controlled water absorption rates.

Most soy flours and grits are prepared from beans which have been dehulled, flaked and the oil solvent extracted by conventional means. Soy flour and grits have the same general chemical composition, but differ in particle size. The products referred to as flour are ground so that nearly all of the product will pass through a U.S. 100 mesh sieve, although most of the commercial soy flour products are ground so that nearly all will pass a U.S. 200 mesh sieve. For some special purposes they are ground still finer so that nearly all will pass a U.S. 300 mesh sieve. With the

TABLE I

Typical Analyses of Soy Products (MFB)

Flour and grits		S.P.C.	I.S.P.
Protein	56.5	71.0	96–100
Fat	0.9	1–3	0.1
Fiber	2.7	3–4	0.1
Ash	6.5	3–5	2–5
CHO	33.0	21–30	....

grit products, they are coaser ground products which are separated into desired particle size usually through a screening operation, with the particle size choice depending upon the application. For example, a 10/40 grit is one where nearly all of the product will pass a U.S. 10 mesh sieve and most of the material is held on a U.S. 40 mesh sieve. A 5/20 grit would similarly be a product where nearly all passes a U.S. 5 mesh screen and most of the product held on a 20 mesh screen. While there are some full fat soy flour and grits produced from dehulled beans by cooking and grinding, the use of the full fat type of product is very small in relation to the defatted materials. The terms soy flour and grits have been used rather loosely, but defatted soy flakes can be processed by various procedures to give many different products.

If one were to carry out the process for preparing soy flakes through the dehulling, flaking and solvent extraction and the excess solvent removed from the fat free flakes with a minimum of heat, in essentially the absence of moisture, one will obtain a flake which is often referred to as a white flake. Such a flake usually has a water dispersible protein of over 90% (based on total protein), high enzyme activity and a beany bitter flavor. This flake is rarely used as a grit, but is ground to soy flour and is used in baking. This type of flour is used for its enzyme active property, more so than for functional properties or added nutritional value, and is referred to as an enzyme active soy flour.

In England, the enzyme active soy flour products are of the full fat type while in the United States, defatted enzyme active soy flour is more common. In England it is reported that 95% of white bread is produced using 0.75% of an enzyme active soy flour. In the United States, Federal Standards limits the use of enzyme active soy flour to 0.5 parts to each 100 parts of wheat flour. The enzyme active soy flour contains the enzyme lipoxidase which has a bleaching action on wheat flour and gives improvement in flavor and color of breads. During baking, the enzyme activity is destroyed and undesirable flavor components of the soy flour are lost so that the finished baked product has an acceptable flavor. If this soy flour is used at higher levels, there would be a soy flavor imparted to the bread.

Earlier reference was made to dispersibility of the protein in water. In the literature there are a number of terms which have been used to connote water dispersibility of proteins. Various terms such as water dispersible protein (WDP), protein dispersibility index (PDI), nitrogen solubility index (NSI), water soluble protein (WSP), have commonly been used as an indication of the degree of denaturation of the protein in protein-containing products, in order to correlate the functional characteristics of protein-containing products with the degree of denaturation. The procedures used for determining this degree of denaturation or water dispersibility characteristics have necessarily been empirical. There are a number of factors, such as pH, temperature, particle size of the product on which the determination is made, type of stirrer, rate of stirring, time of stirring, etc., which will influence the results obtained. When a procedure is set up and all known variables are controlled, the results obtained in a given laboratory by a given technician can be repeated with a reasonable degree of accuracy. However, results obtained in one laboratory may not always be accurately duplicated in another due to differences in techniques of the operator or variables which are not controlled from one laboratory to another. Several years ago two procedures were adopted as tentative and published in the "Official and Tentative Methods of the American Oil Chemists' Society." These two procedures have sometimes been referred to as the fast stir and slow stir methods. While there does appear to be some correlation between the two methods, particularly in the higher water dispersible protein ranges, it would seem highly desirable for those concerned with this procedure to finally agree on one terminology in order to have less confusion in future literature and a better understanding among all involved.

Over the years some correlations have been obtained between the functional characteristics of soy flour and grit products and NSI (defined as the percent of total nitrogen in a sample which is water dispersible based on method used) in various applications.

In producing soy flour and grit products with different NSI values, moist heat is used in appropriate equipment. Again, a number of factors must be considered in producing standardized products for use in different applications. While NSI, per se, may give some indication as to how a soy flour or grit product will function for a given purpose, each user of soy flour and grit products must establish his own specification (and his own analytical procedure) for the soy products to be used in his specific application.

The following data show the results of a study to correlate NSI of a soy flour and its water absorption characteristics (2): NSI 85, per cent water absorption 270; NSI 70, per cent water absorption 385; NSI 55, per cent water absorption 370; NSI 15, per cent water absorption 290. It would appear that as the NSI decreases, water absorption (determined by an empirical procedure) increases to a point and then decreases with decreasing NSI. It is possible that part of this change might be due to the effect of heat on the fibrous portion of the soy flour and grits, rather than on the protein alone.

Dehulled, defatted soy flour and grit products contain about 30% carbohydrates of which about one half is composed of the oligosaccharides which are primarily sucrose (8.2%), stachyose (5.5%) and raffinose (1.2%). The other half are polysaccharides consisting of arabino galactan (8–10%), acidic polysaccharide complex resembling pectic and tragacanthic acids (5–7%) and arabinan (1%) (3).

Moist heat treatment also brings about some other changes. If one were to extract the high NSI product with petroleum ether, the petroleum ether extract would be around 0.4%. When moist heat is applied, the petroleum ether extract increased to approximately 0.8% for products having a low NSI (2).

pH will have an effect on viscosity. If one increases the pH of soy flour slurry from neutrality to around 10 to 11 there is a marked increase in viscosity. Also, when soy flour products which have been moderately heat treated are slurried in water and subjected to temperatures near boiling, they will increase in viscosity. This may be due to changes in the carbohydrate portion whereby polysaccharides may be partially broken down and will have more of a tendency to absorb water, but also undoubtedly due to the gelling properties of both the globulins and albumins which are present in soy flour.

Particle size and particle size distribution often are important considerations as to how a product may perform in a given application. These factors may influence total absorption, the rate of water absorption, the rate of development of viscosity and final viscosity, fat absorption and emulsification characteristics and mouth feel of the final product. With some uses of soy grit products the rate of water absorption may be very important. In certain applications it might be desired to have the product quite fluid for mechanical handling and have it set up later in the process. While some soy grits are used in the baking field, by far the largest portion is used in pet foods and in comminuted meat products. In canned pet foods where meat byproducts and various ingredients are used, it is desirable to have a slurry which can be easily added to the can in high speed canning operations but which will set up during processing. A properly processed soy grit may be made to have retarded absorption so that the cans are easily filled, but the moisture will be absorbed by the grits during the heat processing. Special grits can be produced by compaction procedures or by proper heat processing to accomplish this end. In such grits it is usually desirable to have a product of fairly uniform particle size distribution with very little fine material being present. If fine material is present, it will have the tendency to absorb liquids at a rate faster than the coarser particles, which usually is undesirable, and with the presence of fine materials the final product will have more of a pasty characteristic rather than a chunk like appearance, which is most desirable.

Soy flour with NSI in the range of approximately 50% to 60% are considered the most acceptable type for use in breads, cakes, sweet doughs, cookies, macaroni, dry mixes and donuts. Products with a moderate heat treatment and NSI values in the range of 25% to 35% have the least soy flavor and are most acceptable for use in beverage type products, pancakes and waffles, tortillas, gravies, soup, pudding, sausage products, dietary supplements and baby foods. Products with NSI values in the range of 15% to 25% have found their widest application in calf milk replacers, crackers, beverages, cookies, cereals, baby foods and pet foods.

When soy flour is used in yeast raised baked products, adjustments must be made in the formula, in order to get optimum results. There is usually a decrease in fermentation time which must be taken into account during processing. Additional oxidizing agents, such as potassium bromate are usually required. With the proper use of soy flour in breads, shelf life is extended, breads remain softer over a longer period of time (due to retarded moisture loss), crust color is considered more desirable, and toasting and eating qualities are improved. It is reported that the staling is retarded, possibly due to antioxidant properties associated with the presence of phosphatides and lipoproteins. It is necessary to add about an additional pound of water for each pound of soy flour used in a dough. In one study (4), defatted soy flour was shown to have less effect on the flavor of bread than might be expected. A taste panel of 230 mostly skilled judges failed to identify white bread containing 5% soy flour as different in flavor from bread containing 4% non-fat dry milk solids. Only 3 of 300 judges were able to differentiate between the bread samples in five out of five tests.

Soy flour products are commonly used in donut mixes, frequently in combination with lecithin. In some cases the flour may be lecithinated or a full fat type of soy flour has been used. Addition of soy flour may range from 4% to 10% based on the total mix. Soy flour is usually used in combination with egg yolk to help control for absorption during frying. In one study (2), where a wheat flour mix absorbed 27.6 g of fat/100 g of dry mix, when a defatted soy flour with NSI of about 60% was substituted at a

4% level for the wheat flour, the fat absorption was only 22.8 g/100 g of dry mix. When a soy flour with NSI of 80% was substituted, the fat absorption was 11.1 g/100 g of mix. One problem with the use of soy flour with a high NSI value is that it may impart an undesirable beany flavor to the finished product. Therefore, it is necessary to make some sacrifice between functional value and acceptability of the finished product, so, generally, bakers have settled on soy flour with NSI in the range of 50% to 65% to obtain some functional value and still have good taste characteristics in the finished donuts.

As an illustration of some characteristics of soy flour, McAnelly (5) showed that when he took a soy flour product with 75% NSI and ground it to 65 mesh or smaller, that he could make a dough containing 40% to 60% moisture. He stated that with a larger water to flour ratio the product was not as easily handled, while the use of less water resulted in a dough that was crumbly and difficult to form. The natural pH of the dough was around 6.3. If the dough were made more acidic, the final dried product is harder and more brittle and if the dough were made alkaline to a pH of 8.5 it is quite soft and mushy and the final dried product was more frangible. He believed the products were different because the more alkaline material imbibes considerably more water than the acidic material. A dough at pH 8.5 absorbed about twice as much water as the dough at a pH of 4.5 to 6.3.

While soy products may be used for many purposes, their use has been limited largely due to flavor and the undesirable effect of constituents other than protein, such as carbohydrates, color components and ash. The presence of the fiber interferes with the gelling characteristics of the protein. Soy flour is used to some extent in comminuted meat products, but its use is limited by flavor.

Soy protein concentrates, where much of the water soluble material is removed, including some albuminous proteins, are more acceptable from a flavor standpoint, and a lower percentage may be used to get the desired protein level and equivalent functional value as compared to soy flour. Soy protein concentrate products produced by different manufacturers may have NSI values, based on total protein in the products, ranging from 5% to 70%. Generally the higher the water dispersible protein in a soy protein concentrate the better its emulsifying action. In soy protein concentrates the fiber content increases with the protein, and the presence of the fiber limits its gelation characteristics.

For functional characteristics, the isolated soy protein should have the possibility of rather wide application due to the absence of extraneous materials, high protein content, and functional and physical characteristics of these proteins. Perhaps the most important functional characteristic would be emulsification ability, gel formation properties, water holding properties, film forming properties, adhesive and cohesive properties and aeration properties.

In the meat industry the soy protein containing products are used as so-called binders. The isolated proteins have the more superior binding properties of the soy protein-containing products. When we speak of binding properties we are dealing with a number of considerations (6). While binding may be referred to as that property which holds a mixture of ingredient together, based on adhesive characteristics, it might also refer to the property of preventing or retarding a loss of moisture in foods on storage by binding water. Products which are relatively high in protein, such as defatted oilseed flours, vegetable protein concentrates, isolated vegetable proteins, nonfat dry milk solids and sodium caseinate, and cereals, are all used as binders in meat products. With the possible exception of wheat flour, when cereals are used their value is due to starch gelation rather than fat emulsification.

While there are similarities in physical and functional characteristics, depending on how the various protein materials are treated during the processing, when oilseed proteins are compared to milk proteins there can be some definite differences. These differences may be due to the nature of the processing the protein-containing raw material may receive or to real differences in the proteins themselves.

With isolated soy proteins, it has been established that the degree of heat treatment which may be given to the raw materials used for isolated soy proteins can have an effect on the functional characteristics of such proteins. Japanese workers have shown that when isolated soy proteins are prepared from a starting raw material receiving a minimum heat treatment and having water dispersible protein is a range of 80% or more, that such proteins do not have the gelling properties which one would obtain from proteins from a raw material heat treated to have a water dispersible protein in the range of 50% to 60%. The process used for isolation also will have an influence on these functional characteristics; pH and ionic strength will have a marked influence on the dispersibility of a given protein.

Since the isoelectric points of vegetable proteins from different sources are not the same, one would expect that the binding properties of different proteins in a given system will also be different, although there are no data on this point. Since vegetable proteins in their natural state are not single entities but are mixtures of proteins with different properties as a result of variations in amino acid content, conformation and molecular weight, it would be expected that the method of isolation would change the distribution of proteins in such isolated mixtures. The functional characteristics of such products would be decidedly different.

In the preparation of isolated soy protein and casein, the usual procedure is to precipitate the proteins at the isoelectric point, at a pH of around 4.5 to 4.7, and remove extraneous materials by washing. The isolated proteins are neutralized to a pH in the range of at least 6.5 to 7.0 to convert them to the sodium proteinates, which will have water dispersible characteristics.

With other vegetable proteins, it is possible to solubilize the proteins in water at the natural pH of the products or by adjusting the pH usually to slightly on the alkaline side to get reasonably good dispersion of the proteins, followed by separation of the insoluble matter and precipitating the protein from the dispersion by pH adjustment to that point where the largest yield of protein is obtained. With cottonseed, the isoelectric point of the whole mixed protein is a little below 6.0. However, if a two stage extraction and precipitation process is used to prepare cottonseed proteins, it is possible to obtain one fraction where the point of least solubility is at a pH of 4.0 and another fraction with the point of least solubility in a pH range of 6.5 to 7.0 (7). This latter fraction has a high degree of water dispersibility at a pH of 4 or below, or at a pH of about 8.5 or above. One would expect that such a protein would have quite different functional characteristics than one obtains with proteins such as sodium caseinate or soy sodium proteinate and would function differently in various systems.

Attempts have been made to evaluate the properties of proteins in model systems in the laboratory and to draw conclusions as to what one would expect under practical conditions. One must be careful when trying to apply findings from model systems to the far more complex systems one encounters in preparing a finished food product.

For example, while one can demonstrate that a given type of enzyme hydrolyzed material seems to have certain aeration or whipping characteristics, no one yet has been able to devise a laboratory evaluation which can be used as a fool proof control procedure to determine whether or how such products will function in a complex food system. With angel food cakes where soy proteins are used in combination with egg white, the only known way to determine whether a given enzyme hydrolyzed protein product will give the desired characteristics, when mixed with egg whites, sugars, and flour and whatever ingredients may be added, is to carry out the actual mixing and baking steps one would normally use for producing such a cake. While one can set up a variety of control procedures for producing the enzyme hydrolyzed protein product, there can be no absolute guarantee that products with similar characteristics in laboratory tests will function in a particular angel food cake formulation.

Non-fat milk, sodium caseinate, soy flour, soy protein concentrates and the soy sodium proteinate have been widely used as a binding ingredient in comminuted meat products. In an attempt to develop a laboratory procedure for comparing such products workers at Michigan State University set up a procedure to determine emulsifying capacity and stability of emulsions at different ionic strength and pH value (8). In their procedure, dispersions of the proteins were prepared in water at various levels and the pH and ionic strength adjusted to different values. To determine the emulsifying capacity of these preparations, soy bean oil was added at a definite rate with stirring at a set rate to effect emulsification and to find where the emulsion would break. A sudden drop in viscosity occurred at the breakpoint. They found that there were definite differences between the three protein sources in bringing about such emulsification. At a pH of 5.3 the soy sodium proteinate had little or no emulsifying capacity, but reasonably good emulsification was obtained at a pH value of about 6.9. With potassium caseinate the emulsification was good at a pH of 5.6 and improved as the pH was increased. Non-fat milk solids also showed good emulsification at a pH of 5.6. As a result of these studies they concluded that both potassium caseinate and non-fat dry milk solids would likely produce stable emulsions in sausage, since the pH of such meat emulsions would be in a range of 5.5 to 6.0, but that the soy sodium proteinate would probably produce unstable emulsifications under these conditions. Experience in meat processing plants indicates that all of these products will act satisfactorily as emulsifying and binding agents in meat products under practical production conditions, but the soy sodium proteinate is preferred by many sausage makers. Dutch workers have developed a laboratory procedure for comparing the emulsification activity of protein products which they claim correlates with field results (9).

Emulsifying and binding characteristics of non-fat milk solids, sodium caseinate and soy sodium proteinate were compared in the laboratories of the Central Soya Co. (10). In these studies they used a marginal formulation, which contained 9% meat protein, 35% fat and moisture adjusted to 46%. The protein content of soy sodium proteinate and sodium caseinate was about 90%, and the non-fat milk solids contained about 35% protein. The milk protein products and soy protein were added at levels of 1%, 2% and 3% to these formulations, with all meat ingredients, seasoning, moisture content and preparation conditions being the same. These studies showed that at the 1% additive level there was less fat migration to the surface or, in the terminology of the meat industry, the amount of formation of fat caps was less with the soy sodium proteinate in comparison to sodium caseinate and non-fat milk solids. At the level of 2% soy sodium protein the fat caps were eliminated, while there was severe fat cap formation with 2% sodium caseinate and 3.5% non-fat milk solids. Even at a level of 3% sodium caseinate, fat caps still formed.

Histological sections of these frankfurter products were stained with methylene blue and Sudan IV. Stains showed that a tighter emulsion was formed and more uniform fat distribution was obtained with the soy sodium proteinate in comparison to the milk protein products.

When 10% water dispersions of the soy sodium proteinate were heated in test tubes at 70 C for 30 min, the soy sodium proteinate had set up a solid gel, while the sodium caseinate had not. It may be concluded that the reason for low fat migration in the frankfurter products with the soy sodium proteinate is due to a combination of emulsifying action and subsequent gel formation, which prevents the fat migration. The non-fat milk and sodium caseinate may serve as emulsifying agents, but the meat emulsions were not gelled to the same extent as with the soy sodium proteinate, so fat migrated to the surface during processing.

The binding characteristics of soy sodium proteinate and sodium caseinate were also compared in a study on a tinned pork luncheon meat (Private communication; E. W. Meyer, Central Soya Co.). After cooking at 108 C for 70 min, and cooling, the product was removed from the tins and the juices allowed to drain from a funnel into graduated cylinders. With two different sodium caseinates at the same level as the soy sodium proteinate, the juice which drained from the processed products using sodium caseinate was not appreciably different from the control, but with the soy sodium proteinate the juice draining from product was relatively small. Also in observing the products in the funnels there was less sag in the product containing the soy sodium proteinate in comparison to the control and sodium caseinate products.

In another example showing gelling characteristics and the effect of protein concentration on the sag characteristics, protein dispersions were canned and heated in the autoclave. There was considerable sag at 12% soy sodium proteinate level, but at the 15% level the stand up was much better with concentration at 13% and 14% being intermediate in the sag factor (11).

Circle and Meyer studied the effect of heat for 30 min at various temperatures up to 120 C on the viscosity of dispersions of an isolated soy sodium proteinate (12). With an 8% dispersion at room temperature, the viscosity was around 12 poises; it increased to a maximum of about 700 poises at 80 C and dropped to around 0.1 poise at 110 C. With a

10% dispersion the viscosity at room temperature was a little over 50 poises; it increased to about 2500 poises at 100 C, and dropped off rapidly to around 0.1 poise at 120 C. With 12% dispersion, the viscosity at room temperature was around 600 poises and increased to about 20,000 at 110 C and dropped off rapidly to below 1 poise at a little over 120 C. To illustrate the effect of pH on viscosity, unheated 10% soy sodium proteinate dispersion at pH of 6 had a viscosity of less than 10 poises, and at a pH of 7 the viscosity was around 100 centiposes with little change at pH 7 and 9. With the heated dispersions at a pH of 6, the viscosity was around 2,000 poises with very little change as the pH was increased to around 7.0 and a drop to about 1,000 poises at a pH of 9. In another study when an 8% dispersion was heated at 100 C there was a marked increase in viscosity up to half hour of heating and a marked drop in viscosity as heating was continued for 60 min. When the 8% dispersion was heated at 90 C, a maximum viscosity was reached after 45 min of heating which was slightly higher than that with the 100 C heating in the same period of time, but further heating for 60 min gave only a slight drop in viscosity. When the 8% dispersion was heated at 80 C, a maximum viscosity was reached in about 45 min with little or no decrease in viscosity with further heating up to 3 hr. Dispersions at 10% and 12% concentration when heated to 100 C reached maximum viscosity in about 45 min but further heating up to 3 hr resulted in no further increase or decrease in viscosity of the dispersions.

Another aspect to be considered in the binding characteristics of seed proteins might be the effect on surface tension. It has been shown that surface active agents, such as detergents, improve the binding of meat proteins under certain conditions (13). Soy sodium proteinate also will lower surface tension so part of their binding properties could be due to this surface tension effect in the presence of meat proteins.

With the increasing interest in imitation dairy products, there is a great deal of activity to produce vegetable protein products which can be formulated into imitation milk. None of the isolated vegetable proteins commercially available are completely satisfactory for this purpose. Reasonably satisfactory products can be made with sodium caseinate. There seems to be some difference between presently available soy sodium proteinates and caseinates from the standpoint of their comparative functionality in these items. Just what the physical differences are and what causes them is not known. If one attempts to produce a coffee whitener using the soy sodium proteinate with some formulations in certain coffee brews, there is frequently the problem of feathering. This is not much of a problem when sodium caseinate is used in a properly balanced formula. It is known that methods of processing, mineral balance and types of minerals in the formulation can help alleviate the feathering with the soy sodium proteinate, but no one has yet solved the problem with available types of soy sodium proteinate.

As more is learned about the nature of different proteins and ways of processing and modifying them someone will undoubtedly come up with isolated vegetable protein products either singly or in combination which will have the desired physical, functional and nutritional characteristics to permit food technologists to make a variety of acceptable foods.

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