Meat and Vegetable Protein Blends for Engineered Foods

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ABSTRACT

The meat industry in the United States offers the biggest volume potential for vegetable protein. American Meat Institute reports a 1977 tonnage of 4,377,937,031 pounds of sausage products. Our research with various protein sources is discussed. Emphasis is placed on soy protein products currently available and approved by government agencies. Formulations and requirements for satisfactory products is outlined with economic justifications for soy flour, concentrates and isolates. A thorough discussion of extruded and/or engineered foods is presented showing utilization of mechanically deboned meats, recovered meat proteins from pork and beef rendering, and vegetable proteins in combination with beef and pork. The nutritive values of mechanically deboned chicken and structured soy protein gave PERs over 3.0 with good amino acid balance.

In the future, better, more intelligent use of our food resources is desirable and may be essential for maintaining economic stability in the food industry.

A new and fresh approach must be taken to assess our current supply of meat and vegetable protein products. Our goal must be to use more of the currently available products and develop combinations of new products for sale.

Many attempts have been made to extend existing products, including a term "extenders" for a particular product class. Soy protein and dairy products have been used largely as extenders because of economics.

New technology and developments during the past few years have made possible many new food products. The term "engineered foods" has been used to describe these products.

Our laboratory and USDA-inspected pilot plant has been involved in the testing and development of a number of new products and improvement of existing products. This paper describes our research during the last few years and develops a program for the practical utilization of animal and vegetable combination products.

CURRENTLY AVAILABLE SOURCES OF ADDITIONAL PROTEIN

In past years, we have recycled a large share of the protein produced on farms in the USA. A conservative estimate is that 60% of the protein grown on the farm ends up in the refrigerator of the consumer. This can be explained when we realize that the dressing percentage of a 1,000-pound steer is ca. 60%. After the 60% edible meat goes on the rail, we lose another 20% of the total carcass weight in bone. There is another substantial loss from the fat and lean trimmed off the carcass. Meat meal, tallow and tankage is the usual method of recycling protein and fat.

Some of the products available for edible use are partially defatted pork fatty tissue and partially defatted chopped pork from the carcass. The beef counterpart is partially defatted beef fatty tissue (PDBFT) and partially defatted chopped beef (PDCB). These proteins are taken from the edible product during rendering by means of a centrifuge system at different temperatures (less than 48 C) and fat levels.

The current tonnage estimate of partially defatted chopped beef is 20-25 million pounds per year produced by 10 companies (1). Current prices are 15-18 cents per pound on PDBFT and 35-40cents per pound on PDCB, FOB Chicago, Illinois. Nutritive values are good when the products are used in combination with other protein sources (2).

Other products from the meat industry available for use include mechanically processed beef and pork. These products are obtained by using edible bones and processing them through a system for removing the adhering meat and meat tissues. Current USDA regulations permit use of these products under restricted conditions and these conditions are outlined in Table I. It has been estimated that more than 1 billion pounds per year are available for consumption in the USA alone. Enough additional sausage tonnage is available to feed 40 million more persons; their requirements are based on 1977 consumption figures. Political and legal decisions, not scientific facts, have caused the demise of this once promising source of more animal protein in the USA. Canada permits mechanically debonded meats to be used without the restrictive labeling.

Recent developments include recovery of protein tissue from beef rumen, reported by Oregon State researchers (3). The tissue had good emulsifying capacity and was equivalent to skeletal muscle protein in stability. Swingler and others from the University of Nottingham in England have recently prepared protein isolates and spun fibers from meat by-products (4). Another animal protein that has been extensively studied by workers in the USDA and Texas A&M University is a blood protein recovered, purified and added to sausage products. Rubin (5) has a good review of collagen and bone protein.

The poultry industry has two major products currently available and being used. These products are called mechanically deboned chicken and mechanically deboned chicken meat. The mechanically deboned chicken is made from necks and backs of broilers by processing through a mechanical meat processing system. We have had a major development contract with Protein Foods Corporation of

TABLE I

Mechanically Processed Meat Products
Labeling Requirements U.S.A.

Name:	Mechanically processed (species) product.
Qualifying phrases:	Made with mechanically processed beef or mechanically processed pork. Contains up to_____ percent powdered bone.
Limit:	20% of the meat block in sausage products.
Quality:	Fat less than 30%.
	Minimum 14% protein.
	PER - 2.5 or greater.
	Also bone size controlled.

TABLE II

1977 USDA Poundage Report
Inspected Products (7)

	Million pounds
Cured beef and pork products	4,452
Smoked, dried or cooked	4,148
Fresh and frozen products	37,857
Sausage	4,378
Sliced and packaged products	2,820
Miscellaneous meat products	755
Canned products	3,008

Canada and with its plant in Gainesville, Georgia. We have assisted in developing several consumer products. The equipment being used in the plant in Gainesville, Georgia, can produce 100,000 lbs per day of mechanically deboned chicken from chicken necks and backs that would normally go to pet foods. Another product produced in the same plant is a product referred to as mechanically deboned chicken meat. Chicken meat is produced by removing the skin from the necks and backs prior to mechanical processing. There are 56 producers of mechanically deboned chicken products in the USA. They produce a total of 110 million pounds per year (6).

The next series of products for consideration is found in the seafood industry. Minced fish is made by running the carcasses after fileting through the deboner and separating the meat from the bone. This practice has been used extensively throughout the USA and other countries over the last 15-20 years. In 1977, 18 million pounds of minced fish blocks were imported into the USA.

Under utilized species of fish can also be recovered using the same mechanical processing system. Our laboratory has been involved in working with the National Marine Fisheries Service and some of the seafood manufacturers to produce products that contain various levels of mechanically deboned or minced fish.

We have worked extensively with vegetable protein products. Extensive tests have been made with various soy products. A contract with A.E. Staley has extended over a number of years and has been used to develop data on the use of Procon, soy protein concentrate, as an extender and milk replacer in a number of meat product formulas, including fresh and processed meats.

Soy protein concentrate has the advantage over soy flour of no soluble sugars to cause flatulence. However, soy concentrate has an equivalent PER because little protein is removed during processing. Isolates have lower PER values due to protein fractionation during processing.

We have also tested and developed meat formulations for a soy isolate produced by Dawson Mills.

Utilization of soy protein products in meat-food systems depends largely on the lack of soy flavor. The soy protein isolates have classically possessed lower soy-like flavors than other soy protein products. The soy protein concentrate, Procon, has flavor equal to or better than isolate. This concentrate also allows more versatility with a flour, grit, and textured form to fulfill any texture parameter in meat-food systems. The concentrate has a controlled hydration rate which provides minimum shrink loss and maximum juiciness in such items as beef, chicken, and pork rolls or logs.

The functional ability of Procon to be used in emulsion items as a binder of both fat and water has been displayed worldwide. Procon's ability to absorb water and fat during processing as well as reheating is an advantage over "gelling" type proteins. The "gelling" type proteins also create a lack of juiciness and flavor by totally tieing up water and fat.

Our contract work with Ralcon Foods investigated the use of structured protein fiber developed from soy isolate. It has outstanding textural properties when combined with certain types of food products. The fiber, produced by Ralcon Foods, is a structured, nutritious, hollow, flesh-like fiber sold frozen in 50 pound blocks. When the fiber is used without grinding, it offers a means of putting structure and texture back in emulsified or finely ground products such as mechanically deboned meats and poultry. Our initial work with another textured soy isolate–spun fibrils from Dawson Mills–indicates similar application potential.

A number of interesting yeast products are currently available in the USA. The product with the most research and testing in our laboratory is produced by Amoco Food Company and offers the advantage of a high quality protein and flavoring characteristics that are not available in most other sources of vegetable protein. The torula yeast protein has a good potential with the new engineered food products.

Peanut protein research has been conducted for the Georgia Peanut Commission to examine the characteristics and utility of peanut protein in various meat systems. The main advantage of the peanut protein is lack of flavor so that high levels can be used without creating a texture or sensory problem. The World Protein Corp. in Fort Lee, NJ, makes Nutrex peanut flakes – full fat with 51% oil and 29% protein, partially defatted with 30% oil and 41% protein, and defatted flakes with 1% oil and 60% protein.

TABLE III

Federally Inspected Products (7)
Total Tonnage in 1977

Frankfurters	Bologna	
80%	72%	All meat
10%	9%	With extenders
3%	11%	With variety meats
7%	8%	With extenders and variety meats

EXTENDERS

In the USA the biggest target for use of vegetable and dairy protein products is the extension of meat and meat products. Table II shows the 1977 USDA poundage report of inspected products (7). This table shows that the ratio of fresh and frozen meat is 2:1 over the rest of the meat products. Even so, sausage, sliced and packaged products, total over 7 billion pounds annually.

Extenders are used in meat at various levels from 2%, in the case of isolated soy protein, to 3½% for most milk and soy protein concentrate blends. A number of loaf products are extended in the 8-10% range with various flours and combinations of whey, caseinate, soy protein, and yeast products.

The data presented in Table III show the federally inspected total tonnage for franks and bologna as a percentage of each product class extended and the percentage of extension. If we take the actual frankfurter and bologna pounds extended and assume that 50% of the rest of the sausage loaf and sliced products are extended at an average level of 6%, then we used 56 million pounds of extenders in 1977. With a total tonnage of over 7 billion pounds, the combined product classes give about 0.7% extension of all sausage products. This level of extension is realistic and points out the tremendous opportunity to combine vegetable-protein sources with meat blends in the USA. We did not add imported products or state-inspected totals since they are not available. We estimate these would contribute less than 15% to the total.

ENGINEERED FOODS

Consumer interest in nutritional content of foods has

increased dramatically during the last few years and will continue to increase as scientific studies report on results of nutrition and foods for health. Congressional hearings, USDA research programs and FDA press releases are predicting detailed nutritional labeling in the very near future. In fact, bills are under congressional consideration to extend the detailed nutritional labeling and make it mandatory.

Food processors are discussing structured foods designed to meet specific nutritional and marketing needs. The meat industry is the largest food industry in the USA, and meat makes up a relatively high percentage of the total cost of our diet. Combination meat-plant protein-extruded (engineered) foods offer attractive possibilities to overcome both cost and nutritional problems. Fat can be closely controlled; protein from several sources can be combined to give a higher quality protein. Plant protein can be extruded before addition to produce varied bite and other eating characteristics.

Utilization of ham tumbling and massaging technology to produce beef, pork, and poultry rolls or logs is growing rapidly. The roll or log products offer distinct advantages for portion control and versatility over whole muscle roast products. The log can be sliced, diced, ground, or chopped with the efficiency of end-to-end processing and controlled fat content. The addition of soy proteins to these products allows higher yields and juicier products. The use of such functional proteins also creates a more economical product with higher protein.

The current controversy over nitrite indicates that our eating habits with respect to cured meat products may be in for change. With the new extruded (engineered) food concept, nitrite levels can be reduced and in some products eliminated. Careful control to optimize the amount of additives and eliminate natural contaminants is possible.

In our search to find a better system, Wenger Manufacturing Company has joined with our research group to produce a low shear extruder coupled with a drying-heating oven. With this combination, we can produce meat and vegetable protein strips and sausage products that will greatly improve the operating efficiencies of the meat plant. The meat strips and sausages are being produced in a continuous process with a minimum of manual labor after the raw ingredients are placed in the mixer. The mixed ingredients move automatically to the extruder where they are cut and shaped and then move into the oven. From the oven, the finished products move directly to an automatic packaging line. Complete time lapse from weighing the ingredients into the mixer through packaging is ca. 45 min. This compares to 5-12 hr required for any meat operation to produce similar type products using conventional equipment and smokehouses.

Complete pilot plant lines for producing the meat-based extruded product have been established at ABC Research, in Gainesville, Florida. Basically, the line is composed of scales and mixer at the infeed of the extruder, the low shear extruder, a drying-heating oven, and packaging equipment. The oven can be used for heating-drying only, or can be used for conventional smoking if the conventional smoke is preferred to a liquid smoke seasoning. Necessary auxiliary equipment is available, and the entire facility meets USDA requirements (USDA Inspected Establishment 7336).

Freezers, refrigerators and a meat pilot plant with complete chemical and microbiological facilities are already located at ABC Research. The extruder is newly developed, low shear, low pressure forming, with particularly efficient heat transfer capabilities. The jacketed extruder barrel is thin for better heat transfer, and the hollow flight screw permits either heating or cooling of many products that due to their sensitivity do not lend themselves to cooking or forming in a conventional high shear extrusion cooker. The jacketed barrel is engineered for maximum heat transfer facilitating both steam heating and cooling with water or glycol. The extruder has the capability of extruding products in various shapes, including round items with various diameters and flat products with widths of 2-3 in.

Initial work to develop feasibility concepts resulted in the production of breakfast strips, small sausage products, and beef jerky. These breakfast strip products contained ca. 28% protein, 42% moisture, 16% fat. The water activity is lower than conventional meat products.

By combining various sources of protein, such as yeast, soy, milk, casein, etc., the amino acid content can be balanced, and it is possible to upgrade protein quality and at the same time reduce costs. To meet the demand for additional fiber foods, fiber ingredients can be added. All types of meat protein are being considered, including chicken, turkey, beef, pork, fish, partially defatted beef and pork fatty tissue, mechanically deboned meat and other emulsified products. Potential benefits from the use of the pilot plant will be more fully developed with additional work.

Recently, the FDA published a section in the Federal Register (8) and outlined the provisions for handling and fortification of substitutes for meat, seafood, poultry, eggs, or cheese which contain vegetable protein products as protein sources. Since the regulation was designed for new food products combining both meat and vegetable protein, we share with you paragraph 102.76 of the tentative final regulation.

Paragraph 102.76 Substitutes for meat, seafood, poultry, eggs or cheeses which contain vegetable protein products as protein sources.

(a) This section applies to any food which meets the following conditions unless other Federal requirements provide for the use of another name:

(1) It substitutes in whole or in part for a major protein food, i.e., its presence in another food results in the presence of a smaller amount of meat, seafood, poultry, eggs, or cheese than is customarily expected or than appears to be present in that food.

(2) It contains one or more of the vegetable protein products for which common or usual names are established in paragraph 102.75 as a source of protein, and those amounts of water, fat or oil, colors, flavors, and any other added substances necessary to make the resultant mixtures resemble the meat, seafood, poultry, eggs, or cheeses for which they substitute. These added substances may be part of the food at the time of sale or may be added by the purchaser.

(b) The common or usual names for a substitute for meat, seafood, poultry, eggs, or cheese shall include the term "vegetable protein product" and may include the term "textured" or "texturized" and/or a term which accurately describes the physical form of the product, e.g., "granules," when such term is appropriate. The term "plant" may be used in the name in lieu of the term "vegetable."

(c) When a product described in paragraph (a) of this section bears in its label, labeling, or advertising any representation of flavor, the common or usual name shall be accompanied by an appropriate flavor declaration as required by paragraph 101.22 of this chapter, e.g., "artificially ham flavored vegetable protein product."

(d) Unless other Federal requirements provide for the use of another name, when a substitute food described in paragraph (a) of this section contains an animal product(s) added for protein content, for functional purposes or for any other purpose (e.g., milk protein, fish protein concentrate, animal fat), the name of the substitute food shall be accompanied by a statement such as "containing _____" or "contains _____," the blank to be filled in with the name(s) of the added

animal product(s). Such statement shall be in type no less than one half of the size of the type in the name of the substitute food.

(e) When a food contains one or more vegetable protein product ingredients, each such ingredient shall be listed by source (e.g., soy or peanut) and product type (i.e., flour, concentrate, isolate) in the ingredient statement as required by paragraph 101.4 of this chapter. For example, in a blend of soy protein concentrate, peanut protein isolate, and soy flour, which is permitted by paragraph (b) of this section to bear the name "vegetable protein product," each of the three vegetable protein ingredients of the blend shall be identified as such in the ingredient statement.

(f) A food which resembles and is used for use as a substitute for meat, seafood, poultry, eggs, or cheese as described in paragraph (a) of this section, but which is nutritionally inferior to that animal protein food which it resembles and for which it substitutes, shall be labeled as an imitation of the animal protein food which it resembles and for which it substitutes, pursuant to paragraph 101.3 (e.) of this chapter. For purposes of paragraph 101.3 (e.) of this chapter, a substitute food shall be considered nutritionally equivalent to the major protein food for which it substitutes if it meets the following conditions:

(1) (i) When the substitute food is represented for use in such a way that it resembles and substitutes for breakfast meats (e.g., bacon or sausage) or lunch meats (e.g., frankfurters, bologna, or luncheon meat), whether or not such use involves mixing with the food for which it substitutes:

(a) The substitute food contains at least 13 percent protein by weight when formulated to resemble the breakfast or lunch meat, and

(b) The substitute food contains the following levels of nutrients per gram of protein:

Nutrient	Amount
Vitamin A(IU)	13
Thiamine (milligrams)	0.02
Riboflavin (milligrams)	.01
Niacin (milligrams)	.3
Pantothenic acid (milligrams)	.04
Vitamin B_6 (milligrams)	.02
Vitamin B_{12} (micrograms)	.1
Iron (milligrams)	.15
Magnesium (milligrams)	1.15
Zinc (milligrams)	.5
Copper (micrograms)	24
Potassium (milligrams)	17

(ii) When the substitute food is represented for use in such a way that it resembles and substitutes for seafood, poultry, or meats other than those described in paragraph (f) (1) (i) of this section, whether or not such use involves mixing with the food for which it substitutes:

(a) The substitute food contains at least 18 percent protein by weight when formulated to resemble the meat, seafood, or poultry, and

(b) The substitute food contains the following levels of nutrients per gram of protein:

Nutrient	Amount
Vitamin A(IU)	13
Thiamine (milligrams)	0.02
Riboflavin (milligrams)	.01
Niacin (milligrams)	.3
Pantothenic acid (milligrams)	.04
Vitamin B_6 (milligrams)	.02
Vitamin B_{12} (micrograms)	.1
Iron (milligrams)	.15
Magnesium (milligrams)	1.15
Zinc (milligrams)	.5
Copper (micrograms)	24
Potassium (milligrams)	17

Our contract work has covered many types of engineered or extruded foods, but the most interesting developments have been with Singleton Packing Company and the Autoprod extruder. A number of seafood products have been developed and are being marketed in their product line.

The extruded foods can be put through a batter and breading process if desired. The products can be fully cooked prior to packaging as an optional processing technique. Onion rings and potato chips are two products moving rapidly into extrusion technology. We plan to apply this concept to the meat industry.

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