Meat and Dairy Analogs from Vegetable Proteins

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ABSTRACT

The enormous pressures for protein food products in the coming decades, brought on by world population increases, will be solved through the extension of traditional animal protein foods with vegetable proteins and through the development of food products based on vegetable proteins alone. Analogs of beef, fish, poultry and other traditional animal protein products, which are based solely on vegetable proteins, are an established food category, and are expected to increase market share. Dairy analogs based on vegetable protein are currently marketed in the form of simulated cow's milk and dairy desserts. Vegetable forms of cheese and other milk protein products are also expected to increase. Nutritional equivalence of vegetable protein products is fundamental to product design. Protein and fat content must be standardized. Vegetable proteins are blended to reach desirable protein quality. Analogs currently marketed are primarily blends of soy and wheat proteins containing lesser amounts of yeast and egg albumen. The products are fortified with vitamins and minerals to levels present in animal protein foods. Processed meat manufacturing facilities, which exist in most developed countries, can be readily adapted to produce meat analogs. The technology which has been developed to date is based on soy or soy/wheat combinations. The technology can readily be adapted to other vegetable proteins such as rapeseed, cottonseed, sesame or sunflower. These protein sources, while in abundance in many countries, need process research which can refine them for human use. The vegetable proteins offer the world's exploding population a virtually untapped resource for its burgeoning food requirements.

INTRODUCTION

This World Conference has provided a forum for a comprehensive, scientific, regulatory, and marketing exposure to the very broad field of vegetable proteins. Quite logically, most of the information which has been presented has dealt primarily with the blending of vegetable protein products with animal proteins. Varying percentages will be used to extend or inflate the amount of animal protein which will be available for human consumption.

Experts have discussed the dramatic increases in world population projected in the next fifty years. The economic and political challenges which must be met in order to meet these enormous demands from a production and food delivery system point of view are very complex. Meat and dairy analogs – high technology, sophisticated food products – hold a share of today's market and are projected to gain an increasingly larger percentage of market share as the requirements for protein foods accelerate into the twenty-first century.

DEFINITIONS

It is important to define the term "analog" so that we may clearly establish the ground rules by which our food technologists, regulatory agencies and marketing department must operate. In our laboratories we define "analog" as "a food product which is designed as an alternative to traditional animal protein foods, such as; meat, poultry, seafood or dairy products."

The key term in this definition is the word "alternative." Analogs are not merely substitutes for animal protein products but an entirely separate class of food products. It is our position that the marketing and consumption of vegetable proteins should not in any way deter the expansion of the manufacturing and sale of as much animal protein as the world can reasonably be expected to produce in the years ahead. The plain facts are, while there will be substantial growth in animal protein products, it will be literally impossible to keep up with demand. The widening gap between demand and available supply for protein must be filled by vegetable protein products of which analogs will be a larger and larger factor.

The analog will be familiar to the consumer in terms of its functional characteristics, such as, appearance, texture, flavor and color. Most importantly, it will be nutritionally equivalent to the traditional animal products for which it is presented as an alternative food.

Meat Analogs

The earliest meat analogs were developed by Dr. John Harvey Kellogg and presented to his patients in his Battle Creek, Michigan sanitarium as early as 1898. These products were based exclusively on wheat gluten which was obtained by the washing of starch from high protein wheat flour. More recently, and particularly since 1955, the pioneering work of Warren E. Hartman and Robert A. Boyer blended the proteins from soy, wheat, yeast and egg albumen resulting in products for the Worthington Foods Company. These products were designed to satisfy the nutritional needs of many religiously motivated vegetarians. These developments formed the base of the present day technology for the manufacture of meat analogs.

Dairy Analogs

The most widely known examples of dairy analogs, of course, are margarine, whipped toppings and nondairy coffee whiteners. These products have achieved worldwide success in the marketplace in the last thirty years. During this same period, the simplest of the dairy analogs, simulated cow's milk, has been marketed for infants who exhibit allergic reactions to the bovine product. Using this technology as a base, analogs of cheese, ice cream and other milk-based desserts have been developed.

DESIGN OF MEAT ANALOGS

The greatest challenge to the food technologists in the

TABLE I

Micronutrient Content of Selected Meat Products[a] and Analogs

		Values per gram protein				
		Required for analogs[b]	Pork sausage (no.2013)	Hamburger (grd. beef) (No.369) regular	Steak sirloin (no.287)	Bacon (No. 125)
Vitamin A	(I.U.)	13.0	(0)[c]	2.2	3.0	(0)[c]
Vitamin B_1	(mg.)	0.02	0.05	0.005	0.004	0.04
Vitamin B_2	(mg.)	0.01	0.007	0.006	0.005	0.009
Vitamin B_6	(mg.)	0.02	0.01	0.02	0.02	0.01
Vitamin B_{12}	(mcg.)	0.10	0.06	0.12	0.09	0.12
Niacin	(mg.)	0.30	0.24	0.24	0.24	0.21
Pantothenic acid	(mg.)	0.04	---[d]	---[d]	---[d]	---[d]
Copper	(mcg.)	24.0	9.0	12.7	5.9	12.1
Iron	(mg.)	0.15	0.15	0.15	0.15	0.14
Magnesium	(mg.)	1.15	0.96	0.95	1.0	1.43
Potassium	(mg.)	17.0	14.9	13.2	13.0	15.5
Zinc	(mg.)	0.50	0.12	0.21	0.18	0.11

[a]Values are from USDA Handbook No. 8, supplemented by Miles internal assays.
[b]Common or usual name proposal, Vegetable Protein Products, U.S. Food and Drug Administration Federal Register 43, No. 136, p. 30471 – July 14, 1978.
[c]None or too small to measure.
[d]No available data.

design of these sophisticated food products is in the area of taste and texture. Manufacture of meat analogs parallels very closely that of processed meat, such as, bologna, salami, precooked sausage and frankfurters. However, when the raw materials are vegetable in their physical characteristics, particularly regarding taste, they are extremely difficult to flavor. Many of the major flavor houses in the world have aggressive research programs designed to develop meat flavors which will be used to impart the flavor of animal protein to the vegetable protein bases. Significant progress has been made in several areas, particularly those of pork, bacon, ham, and beef fat. Appropriate artificial seafood flavors are currently receiving a great deal of attention but thus far are lagging, particularly in terms of their ability to withstand even the mildest of processing conditions.

Nutrition

Vegetable protein analog products, because they may include almost any nutritional attribute, can clearly be designed to correct or improve nutritional qualities inherent in a diet based largely on animal protein products. For example, meat analogs contain no cholesterol and can have a favorable polyunsaturated to saturated fat ratio. Moreover, the protein levels can be increased if this is desirable. The fat levels are almost always reduced for the products. This results in less caloric density, an attribute widely sought in products utilized in weight reduction diets.

The micronutrient content of analogs is carefully controlled. Vitamins and minerals can be added to the products at virtually any level. Standards for vegetable protein products have recently been published by the U.S. Food and Drug Administration. The micronutrient requirements are set forth in Table I along with a comparison of the levels normally found in several meat products.

Protein Efficiency

The meat, poultry, or seafood analogs marketed by Miles Laboratories are designed to have a PER of 2.5 or higher. The subject of PER and its relationship to human nutrition in contrast to rat or other animal nutrition has been discussed in detail at many recent conferences including this one. The controversy involving this test and its applicability to products for human nutrition will not be resolved in the short term. Our technology does allow us to meet these goals through appropriate blending of the proteins from wheat, soy and egg albumen. We do urge a continuing research program by academia, industrial scientists, and regulatory agencies in an attempt to derive a shorter, more meaningful test of protein utilization in the human diet.

MARKETING OF MEAT AND DAIRY ANALOGS

Meat analogs are marketed in the U.S. by Miles Laboratories under the Morningstar Farms and the Worthington Foods labels. A wide variety of products is also available from Loma Linda of Riverside, California. General Foods is test marketing a bacon analog. Ross Laboratories and Mead Johnson market infant soy milk preparations. A cheese analog based on milk protein with corn oil is marketed by Kraft Foods. Fisher Cheese Company of Wapakoneta, Ohio, markets cheese analogs based on vegetable protein and vegetable oils.

Most analogs are marketed today on the basis of their health and nutritional benefits. Morningstar Farms products are designed to be used as part of a total dietary program through which the consumer can reduce intake of saturated fat and cholesterol. The Worthington Foods products are designed to provide the vegetarian consumer with high quality protein and a minimum of fat. The soy milk products are designed to provide infants all the protein, fat, carbohydrates and micronutrients of cow's milk. General foods' bacon analog, however, is marketed on the basis of "good flavor at lower price." In today's market, on a cost comparison basis, the meat and dairy analogs generally are equivalent to their animal counterparts. Some are even more expensive. The Morningstar Farms products, frozen convenience foods offering nutritional benefits, are about equivalent in price to bacon, ham or pork sausage. When the cost of animal protein escalates at the projected rates, the products manufactured from vegetable protein can be marketed with the dual advantage of lower price coupled with health/nutritional benefits.

REGULATORY ASPECTS

It is important that we understand that the regulatory barriers to vegetable proteins currently in effect in many countries must be eased in order to encourage the development of these alternative foods. The world can and will utilize as much animal protein as it can reasonably produce. Products such as meat and dairy analogs must not be viewed as competitors which will have deleterious effects on the markets of traditional animal protein products. Analogs will simply provide the consumer with additional food product choices. Population needs for protein foods,

even in the most fully developed countries, will create enormous demands on production capabilities, far more than the traditional sources can supply. Barriers to the products and to the technology will only delay the long term solution to the inherent problems of providing high quality nutrition. Food science must not be held back, particularly for the less advantaged, who will have an ever increasing demand and nutritional need for these products.

OTHER PROTEIN SOURCES

The meat analog products which are marketed in the U.S. and which we have discussed today are blends of wheat and soy with egg albumen. It is important to note that the technology as currently developed can readily be adapted to vegetable proteins from other sources. Proteins from rapeseed, cottonseed, and sunflower have been processed on a pilot scale. Many countries have large quantities of these oil seed proteins which, by and large, are going into animal feed. We would very much encourage government and/or private industry to initiate research and engineering to develop processes which can result in highly refined vegetable protein raw materials very suitable for human consumption.