Influence of World Fat and Oil Consumption on Protein Supply[1]

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ABSTRACT

Fat and oil consumption has influenced the world protein supply principally through the production of oilseeds among vegetable oil sources, fish oil among marine oils and butter among animal fats. In total amount, oilseed protein production is comparable to world production of protein in red meat and in milk. All oilseed and fish meal protein byproducts and some milk protein byproducts find their greatest use in animal and poultry products production. Increased demand for the latter products with concurrent demand for feed protein has shifted the relative values of oil and meal. Increasingly, oilseed production, like meat production, is producing oil as a coproduct, if not a byproduct, of protein production. Although food use of oilseed protein concentrates is increasing, both as fortificants of traditional foods and in newly developed meat analogs, this market appears unlikely to increase demand for protein concentrates as much as the world demand for increase in animal and poultry products.

Animal fats and vegetable oils have long been valued components in the diet of man, serving not only as important energy sources, but also contributing greatly to the palatability of his food through their functional properties and flavor enhancement. They have also served a variety of nonfood uses: soaps, paints, varnishes, lubricants and many others. In the U.S. and Northern Europe, animal fats–butter, lard and tallow–were the major source of edible fats until the development of the hydrogenation process made it possible for vegetable oils to be converted into margarine and shortening, forms similar to the animal fats to which people were accustomed, but with the advantage of greater flavor stability and, for margarine, lesser cost than its animal fat counterpart.

[1]One of 11 papers presented in the Symposium "The World Supply of Edible Oils and Proteins," AOCS Meeting, Atlantic City, October 1971.

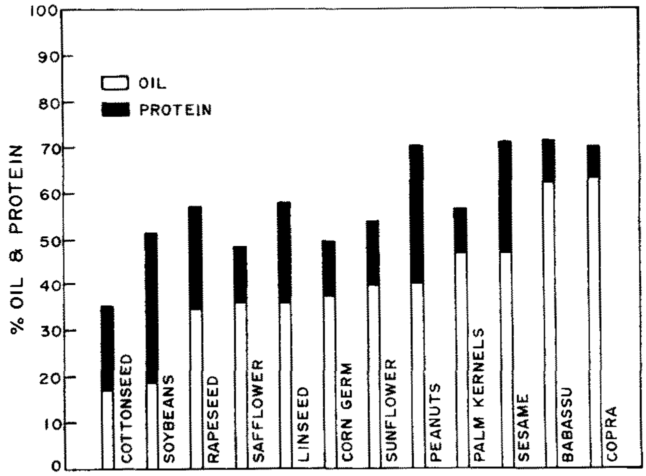

FIG. 1. Processing yield of oil and protein from oleaginous materials.

Hydrogenation thus opened new markets for vegetable oils and stimulated development of the oilseed crushing industry. In the U.S., practice of hydrogenation began with the production of shortening from cottonseed oil in the early 1900's. Added impetus came with the growth of the soybean crop in the 1930's and the demands for edible fats that developed during World War II.

Compared to per capita consumption of fats and oils in the U.S. and Europe, average world consumption is relatively low. U.S. per capita consumption of edible products in 1970 was 52.8 lb., whereas world per capita consumption (including inedible products) was 23.8 lb., less than half the U.S. value (1,2). Foreign consumption, i.e., world less U.S. consumption, was 20.6 lb./person. This average includes the high consumption countries of Northern Europe, which are counterbalanced by the developing countries, such as India, which have per capita consumptions of 10-12 lb. Both U.S. and foreign consumption are increasing, the former currently at the greater rate, 1.3%/year as compared to 0.9%; but the latter, because of its low level, has potential for the greatest growth.

RELATIVE YIELDS OF FAT, OIL AND PROTEIN FROM PLANT AND ANIMAL SOURCES

All sources of fats and oils, both animal and vegetable, also yield a proteinaceous product. In the case of vegetable oils, the oil generally has been the primary and higher-valued product on a unit weight and total yield basis, whereas the reverse situation exists with the animal fats. Animal fats–lard, tallow, white grease–are the byproduct of meat production, but not necessarily of protein production. Milk fat presents a different situation. Separated as butter, milk fat has considerably higher value than the residual skim milk which contains, in the case of cow's milk, essentially as much protein as the fat that was separated. In the U.S. and some other countries, milk is standarized and priced on the basis of its fat content, attesting to the premium placed on fat.

The relative yield of oil and protein from the processing of several vegetable oil sources (3) is shown in Figure 1. Sources are arranged from left to right in order of increasing oil yield, which ranges from 16.9 lb./100 lb.

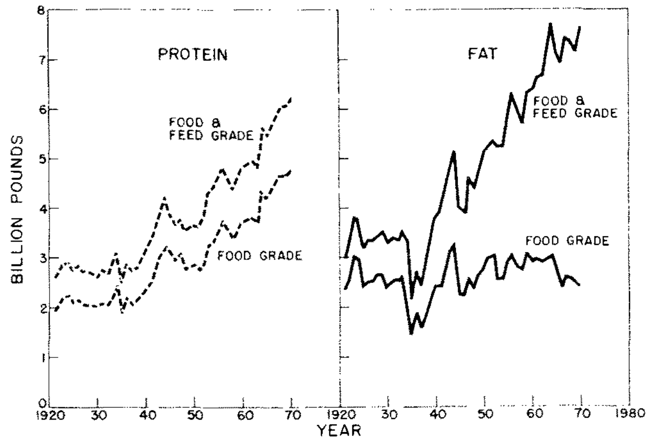

FIG. 2. Yield of protein and separated fat from U.S. red meat production, 1920-70.

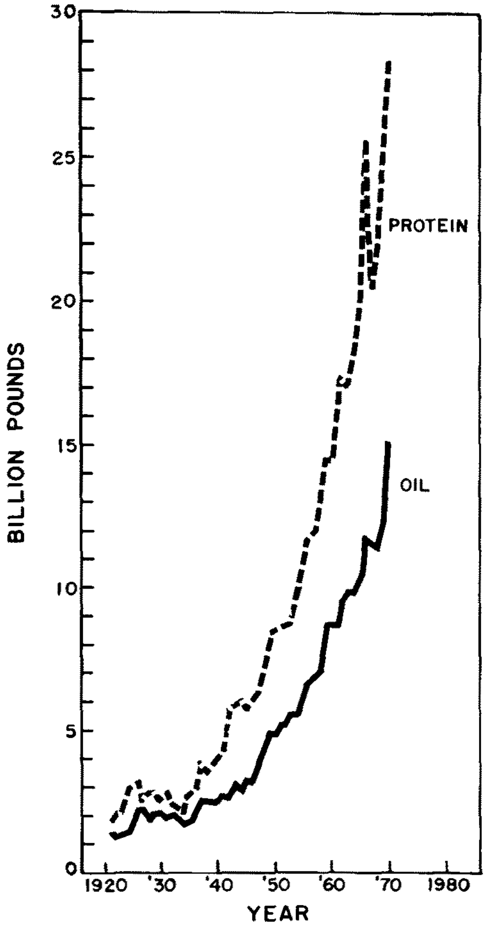

FIG. 3. Comparison of U.S. production of edible proteins and oils from vegetable sources over the period 1920-70.

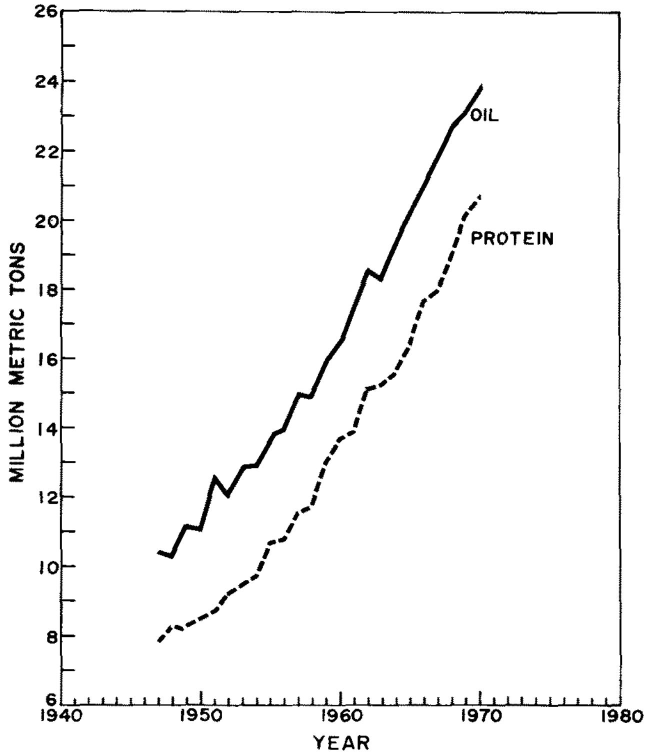

FIG. 4. World production of edible protein and oils from plant sources, 1947-70.

cottonseed to 64 lb./100 lb. copra. As protein sources, soybeans and peanuts are outstanding, the former yielding 35 lb. and the latter 30 lb. protein in the meal from 100 lb. seed. Soybeans are further distinguished by containing nearly twice as much protein as oil and thus might be more properly designated as a "protein seed" rather than an oilseed.

Bars for animal products might have been included in Figure 1. However these bars would need to represent the composition of the raw product rather than the yield of oil and protein on processing as in the case of oilseeds. For the dressed animal carcass, the bar for pork, medium fat class, would show for 100 lb. carcass, 41 lb. fat and 8 lb. protein–the rest would be water and bone. This would be a fat-protein ratio comparable to that for corn germ.

For beef, USDA choice grade, the bar would show 32 lb. fat and 12.7 lb. protein–a fat-protein ratio comparable to that for sesame seed.

For milk, the bar would show 3.7 lb. fat and 3.5 lb. protein per 100 lb. product.

Quantitywise, protein is the lesser component in animal sources. Only a fraction of the carcass fat is separated, however, as lard or edible (food grade) tallow. In 1969, ca. 1.6 lb. lard were produced per pound of pork protein, but only .25 lb. edible tallow per pound of beef protein.

In addition to the food-grade fats, lard and edible tallow, the red meat industry produces a much greater quantity (about twice) of byproduct fats designated as inedible tallow and greases. "Inedible" in this case indicates that requirements for a food-grade product are not met, but does not mean that these products are unsuited as animal feeds. Indeed feed uses constitute a major market for inedible fats.

Substantial quantities of feed-grade protein in the form of meat meal and tankage are recovered through processing of animal viscera, blood, tendons, bone, skin, fatty tissues and other slaughterhouse wastes. Wastes collected from butcher shops, restaurants and other institutions which handle food also are processed into meat and bone meal. From statistics (4-7) for 1920-50 on production of meat meal and tankage and on the carcass weight of red meat animals slaughtered, it was calculated that protein available in byproduct meals was ca. 30% that available as food-grade carcass protein. This factor agrees with estimates based on analytical data on proportion and composition of byproducts from slaughter of single animals (8) and was used in adjusting data collected after 1955, and presented in Figure 2, which includes meat meals from poultry processing plants.

In the succeeding discussion, the yield factors for oil and protein given in Figure 1 will be applied to U.S. and world production data for oilseeds, red meat and milk. We shall attempt to provide some perspective on protein made available as a byproduct of vegetable oil and butterfat production as compared to protein available from red meat production which has fat as a major byproduct.

U.S. PRODUCTION OF OIL AND PROTEIN FROM PLANT SOURCES

U.S. production of edible vegetable oils increased eightfold from 1.8 billion lb. in the 1920's to 15.2 billion lb. in 1970 (9-11) (lower curve on Fig. 3). Most of this increase occurred after World War II. Sharing in this rapid growth were corn oil at a rate of 3.7% annually; safflower oil, production of which had only begun in 1946, at a rate of 23.5% annually; soybean oil at a rate of 9.5% annually from 1.5 billion lb. in 1946 to 7.9 billion lb. in 1970; peanut oil at a rate of 0.64% annually; and edible oil equivalent of oilseed exports at a rate of 39.6% annually from 35 million lb. of oil equivalent in 1946 to 5 billion lbs. in 1970, consisting almost entirely of soybeans. U.S. production decreases have occurred since 1946 for coconut oil and cottonseed oil, the latter as a result of decreased cotton production. Other oils produced in 1970 included palm

TABLE I

Efficiency of Conversion of Feed Protein to Protein in Meat, Milk and Eggs by Livestock and Poultry[a]

Protein	Per cent conversion
Beef	4.6
Pork	12.5
Broilers	17.7
Eggs	23.5
Milk	22.9

[a]From "1965 Production Yearbook," Food and Agriculture Organization of the United Nations.

TABLE II

Dollar Value of Lard Production in the U.S. as Per Cent of Meat Value

Year	Per cent of meat value
1921-30	19.4
1946	13.6
1950	6.6
1960	4.7
1970	3.1

TABLE III

Per Cent of Milk Produced in U.S. Used for Butter Production and Quantity of Byproduct Protein Available in Skim Milk Produced, 1935-70

Year	Per cent of milk produced	Byproduct protein, billion lb
1935	46	1.7
1940	42	1.7
1950	29	1.3
1960	26	1.1
1970	21	0.86

TABLE IV

World Production of Animal Fats (Million Metric Tons)

Fat	1947	1970
Butter	2.6	4.6
Lard	2.2	3.9
Tallow and grease	1.9	4.3
Total	6.7	12.8

kernel and sunflower.

The 11-fold increase in production of edible protein (including protein equivalent of oilseed exports) which came into being was similar to, but greater than, the development of vegetable oil production, and ranged from an average 2.5 billion lb. annually during the 1920's to 28.4 billion lb. in 1970.

It should be pointed out that "edible protein" refers to that in all feed- and food-grade protein meals. Included is linseed meal, which is a byproduct of an oil used for industrial purposes. Production of linseed meal contributed a relatively small fraction of total U.S. edible protein in 1970, amounting to about 0.2 billion lb. of the 28.4 billion lb. total U.S. production. The other major industrial vegetable oils are castor, tung and tall oil. They are not included in the edible vegetable oils; neither do they contribute an edible protein meal byproduct.

Great advances in the science of animal nutrition were made during the 1930's, 40's and 50's, and it was during the latter period that the protein fraction of oilseeds became the product instead of the byproduct on the basis of greater dollar value (12). The edible oilseed protein meals produced in the U.S. found ready markets at home and abroad in animal feeds while soybean meal has been processed into flour, protein concentrates and protein isolates for human consumption as well. Food uses accounted for only a very small fraction of total vegetable protein production, an estimated 237 million lb. of soy protein flours, concentrates and isolates having been produced in 1967 (13). For 1970 we estimate food products used 380 million lb. of soy protein products. The development of textured protein products can be expected to lead to substantially increased consumption of soy and other vegetable proteins as meat extenders and meat analogs in the future.

Practically all vegetable protein produced, however, was fed to livestock and poultry and was converted into animal protein. Efficience of this conversion is shown in Table I and ranges from 4.6% for beef to 23.5% for eggs. The efficiency of conversion is relatively low but it is the most widely practiced method of refining byproduct protein into food-grade protein.

U.S. PRODUCTION OF PROTEIN AND FAT FROM ANIMAL SOURCES

Conversion of the increased vegetable protein production into red meat protein is reflected in Figure 3. Protein from red meat (including byproduct meat meal and tankage) increased 2.2-fold from 2.8 billion lb. in the 1920's to 6.2 billion lb. in 1970. The increase resulted mainly from increased beef production. As noted earlier, byproduct feed-grade protein production was ca. 30% that of meat protein.

In contrast to increased production of food-grade protein over the 1920-70 period, edible red meat fat production remained essentially constant, at 2.5 billion lb. annually. A decline in lard, oleo oil and stearine production during this period was balanced by an increase in tallow production, the latter a result of the increased production of beef. Lard continues to be the major edible animal fat. Indeed it was the largest single U.S.-produced edible fat until the early 1950's when it was surpassed by soybean oil production. In 1969, ca. 1.6 lb. of lard were produced for each pound of meat protein which was ca. 20% lower than 15 years earlier. In contrast, only .25 lb. of edible tallow was produced per pound of food-grade beef protein.

In contrast to the essentially constant production of lard and edible tallow, there was a large increase in feed-grade tallow and grease production. This amounted to ca. 1.3 lb.

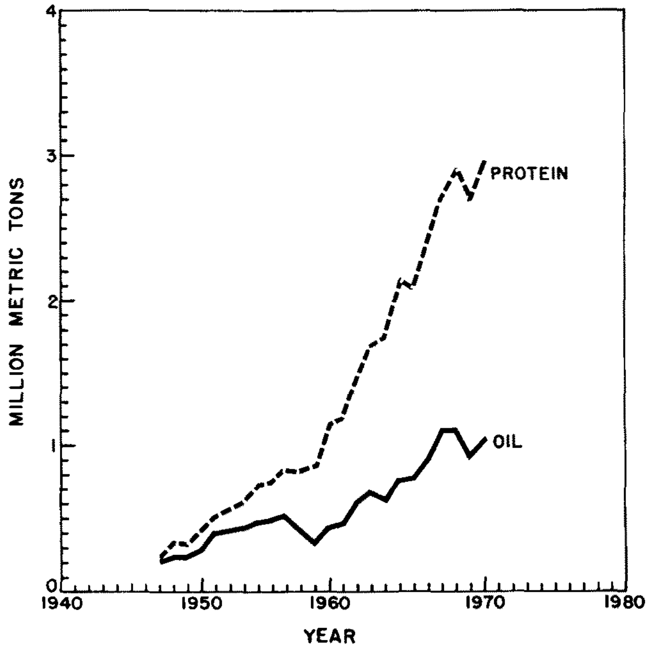

FIG. 5. World production of fish oil and protein.

TABLE V

Influence of World Butterfat Production on Protein Supply: Protein in Byproduct Skim Milk Compared with That in World Red Meat Production

Product	Protein, million metric tons	
	1947	1970
Skim milk	2.4	4.3
Red meat	3.5	8.4
Total	5.9	12.7

TABLE VI

World Protein Production from Major Plant, Animal and Marine Sources of Edible Oils and Fats in 1970 (Million Metric Tons)

Source	Oil	Protein
Oilseeds and palm	23.9	21.2
Red meat and milk for butter	12.8[a]	12.7
Fish	1.0	2.9

[a]Includes inedible (feed grade) tallow and greases.

per pound of meat protein. Total production was 5.25 billion lb. in 1970.

The value of byproduct fat from red meat production is small compared to that of the primary product, meat (Table II). In the 1920's dollar value of lard was 19.4% of the meat value. This was the day of the lard-type hog, when lard was an important product of the pork industry. By 1970, lard value had been reduced to 3% of that of the meat. Total value of edible and inedible fat products for all red meats was ca. 3% of total meat value in 1970.

In the U.S. until 1957, when it was equalled by margarine, butter occupied number one position as a table spread on the basis of per capita consumption. In the 1920's and 30's, up to 46% of milk production went into butter production (Table III). Demand for butter thus made available an approximately equal quantity of protein (ca. 1.7 billion lb. annually in 1935-40) since milk contains about equal concentrations of fat and protein. U.S. butter consumption, however, has declined markedly, and in 1970 only 21% of milk production was used for butter production, making available ca. 860 million pounds of byproduct protein.

WORLD PRODUCTION OF PROTEIN AND OIL FROM PLANT SOURCES

Turning to the world situation, consider first the influence of vegetable and palm oil production on protein supply. Figure 4 presents data for 1947-70, during which time vegetable oil production exceeded protein content of the meals produced by 2.5-3.0 million metric tons. In contrast, protein in U.S.-produced oilseed meals exceeded

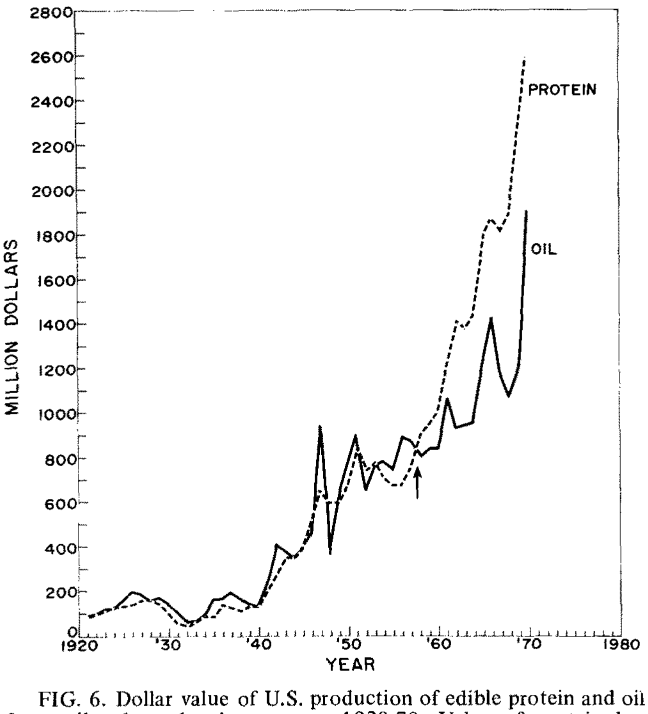

FIG. 6. Dollar value of U.S. production of edible protein and oil from oilseeds and palm sources, 1920-70. Value of protein has exceeded value of oil since 1957.

vegetable oil produced (Fig. 3). This reflects world production of oleaginous crops relatively high in oil content and primarily for oil production as compared to the U.S. production. It can be noted that production of edible vegetable oils and palm oils increased 2.3-fold between 1947-70, while production of edible oilseed proteins increased 2.6-fold.

PRODUCTION OF OIL AND PROTEIN FROM FISH

Another edible protein meal, originally produced as a byproduct of oil recovery but which in recent years has become the primary product, is fish meal. World production of fish meal has increased 12-fold since 1947 (Fig. 5) and in 1970 supplied 2.94 million metric tons of protein, or 14% as much protein as from world production of oleaginous plant materials. Although practically all fish meal now produced is used as a feed ingredient, there has been much interest and considerable activity in the U.S. and abroad in developing processes for the recovery of a food-grade product. Such products are referred to as fish protein concentrates (FPC) and at least one such product is available from a foreign manufacturer. Fish species caught for fish meal production are not desirable for production of the food-grade concentrate, and substantially different processing operations are involved in manufacture of the two products. Loss of functional properties of the protein and production of a bland product have been problems in the production of fish protein concentrate. As these and other production problems are solved, FPC can be expected to become increasingly important as a food protein source.

Fish oil is used both as an edible oil in the manufacture of hydrogenated fat products and in a variety of nonfood applications.

In 1970, world production of edible oilseed and fish proteins had increased such that they almost equalled production of edible vegetable, palm and fish oil. This is largely attributed to increased production of U.S. soybeans with their high ratio of protein to oil and to the growth of the fish meal industry.

Increased world production of vegetable oils and oilseed proteins have been shared by soybeans, cottonseed, sunflower, peanuts and rapeseed. Improved technology and a growing oilseed extraction industry in some developing countries have contributed to the higher world production. For example, it is reported (14) that India's developing cottonseed industry doubled its capacity in the 1960's and was estimated to have expanded its crushings from 18% of production in 1961-62 to 36% in 1970-71.

Regrettably the increased world production of oilseeds and fish meals does not always benefit human nutrition to the fullest extent. Sizable quantities of the oilseeds, or the byproduct meals, are exported from areas of production where nutritional needs are greatest, principally to developed countries for use as animal feed and fertilizer.

WORLD PRODUCTION OF FAT AND PROTEIN FROM ANIMAL SOURCES

Turning to the situation for animal fats, world production of butter, lard, tallows and greases almost doubled

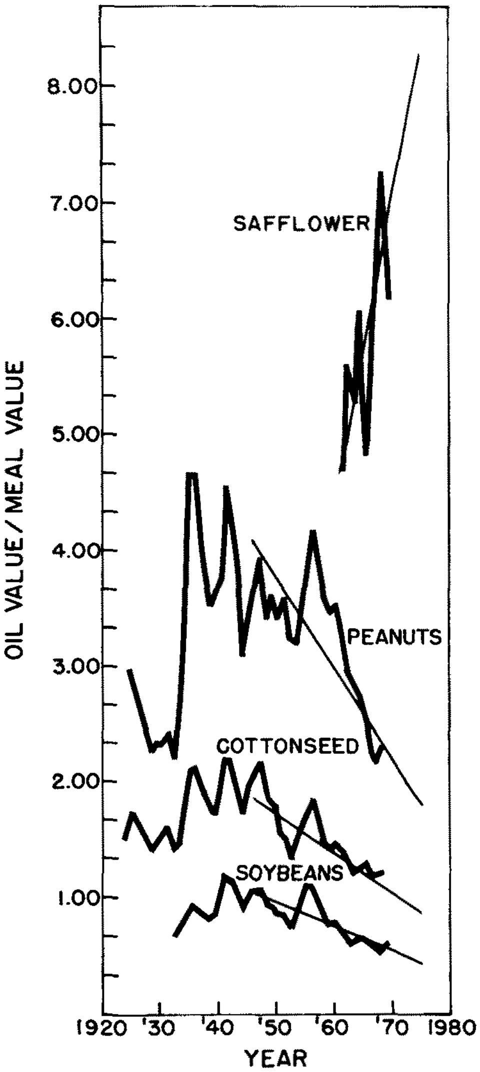

FIG. 7. Ratio of U.S. market value of oil to that of meal for several oilseeds.

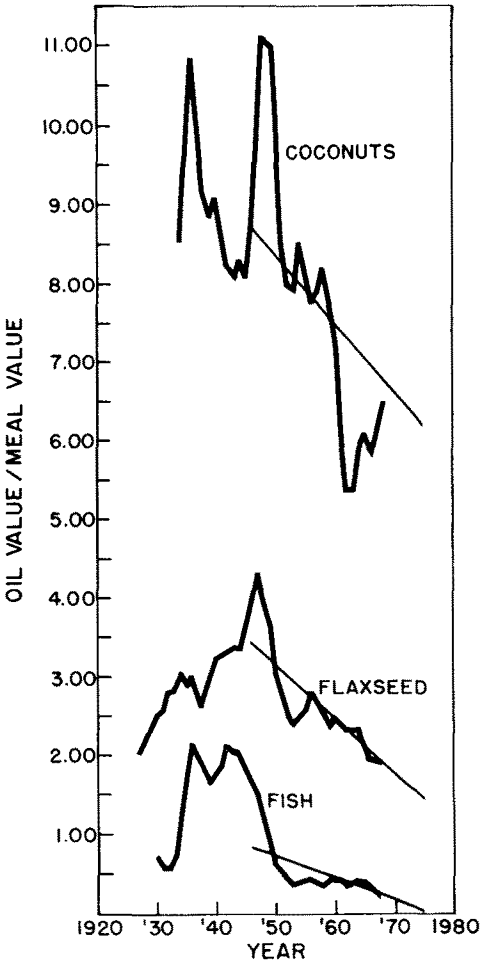

FIG. 8. Ratio of U.S. market value of oil to meal for coconuts, flaxseed and fish.

between 1947-70, increasing from 6.7 million tons to 12.8 million tons (Table IV). Unlike the U.S. situation, world production of butter and lard increased during this period.

World butter production increased an average of 2.6% annually because of increased consumption in developed countries, excluding the U.S. In developing countries, butter production has remained relatively steady. In some developing countries, i.e., India and adjoining countries, and in East Africa, ghee, the best known stable butterfat product, is produced on a large scale (15). It comprises ca. 20% of total Indian annual consumption of fats and oils and is the chief butter produced in Pakistan.

World milk production for butter manufacture has made available relatively large quantities of byproduct skim milk protein. In 1947, the quantity of skim milk protein was 69% of that supplied by red meat (Table V). Byproduct protein from butter production did not quite double, while red meat protein more than doubled in world production from 1947-70. Skim milk protein contributed 4.3 million metric tons to the world protein supply in 1970, 51% of that contributed by red meat. The supply benefits from this increased protein production, however, were confined to the 40 countries where the bulk of production and consumption occurred. Consumption of meat is nearly five times as great in the developed as in the developing countries (16).

If world edible vegetable oil production is compared with animal fat production (Table VI), we find that vegetable oil exceeded animal fats by a factor of almost two in 1970 and amounted to ca. 24 million tons. These vegetable oils brought with them ca. 21 million tons of edible proteins in the form of cakes and meals. This was 67% greater than the quantity of protein available from red meat production and byproduct milk protein from butter production. If, however, all the protein from milk production is included in animal protein production, animal protein production exceeded the vegetable proteins in 1970 by ca. 1.5 million metric tons. This attests to the world importance of milk, both as a protein and a fat source.

RELATIVE DOLLAR VALUE OF OILSEED MEAL VS. VEGETABLE OIL

As evident from the foregoing discussion, processing of oilseeds and palm products for their high unit value oils has produced an increasing supply of protein which has been utilized primarily for animal feed. The increased demand for animal protein products, primarily in the developed countries, has stimulated the demand for oilseed proteins and has caused a shift in the relative dollar value of total oil and protein production. This shift occurred about 1957 in the U.S. (Fig. 6). The ratios of oil value-meal value for several oilseeds are given in Figures 7 and 8. During the 1946-70 period, the ratio of oil value-meal value has significantly diminished for each major oilseed and fish. For the majority of the major oilseeds, oil value-meal value ratio declined at an annual rate of ca. 2.5% over the 24 year period. However the ratio of fish oil value to meal value declined at an annual rate of 5.5%.

Safflower is an exception in that its ratio increased. Safflower meal has a relatively lower price due to its high fiber content, and the price of the oil has been increased by the demand for polyunsaturates.

Increasingly, oilseed production, like meat production, is producing oil as a coproduct if not a byproduct of protein production. Certainly this is the trend in the developed countries whether the protein is to be used for feed or food purposes. Although the advent of technology for manufacture of textured protein products which are meat analogs favors increased use of proteins in food products, this market appears unlikely to increase the demand for protein concentrates as much as the world demand for animal and poultry products. With increasing world population and improvement in economic levels, demand for both natural and analog products will increase. To the extent that analogs replace natural products, which is likely to occur first in developed countries where sophisticated products will be produced, protein demand will be decreased because of the much greater protein conversion efficiency in analog product production as compared to animal or poultry products. Should analogs replace natural products to the extent that margarine and vegetable shortenings have replaced butter and lard, U.S. requirements for oilseed protein and feed grains would both be considerably reduced. Vegetable oil demand would be increased to take the place of byproduct animal fats no longer produced. The extent to which such displacement will occur depends greatly on the extent to which the textured protein products industry, now in its infancy, is successful in simulating natural products and marketing them at lower cost.

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