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FARM *and* FOOD POLICY

BROWNLEE—
Putting Dairying On A War Footing

Rev. ed. pam. cop. 2

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ARM *and* FOOD POLICY

Pamphlet No. 5 *in the Series*

UTTING DAIRYING on a WAR FOOTING

(Revised Edition)

by O. H. BROWNLEE

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FOREWORD

The publication of Pamphlet No. 5 under the title "Putting Dairying on a War Footing" in March, 1943, was followed by protests on the part of certain dairy and farm groups. Representatives of these groups urged:

a. That some of the statements made in the pamphlet were incorrect in whole or in part or were inadequately documented through reference to source material.
b. That certain statements were ambiguous or at least were subject to misinterpretation.
c. That some topics were amplified in the discussion quite beyond that needed to establish the main thesis of the publication. The topics particularly criticized as over-amplified or not pertinent were: those concerning sanitary regulations as trade barriers, the competitive relationships of oleomargarine and butter, and the efficacy of taxation as a means of preventing misbranding and fraud. It was urged that a disservice was rendered to the dairy industry by discussion of the comparative nutritive values of oleomargarine and butter and the significance of state taxes as trade barriers.

Freedom on the part of the members of a research staff such as that of an agricultural experiment station to publish their findings is axiomatic. When publication is regularly or officially sponsored by the station, the manuscripts are reviewed by a staff committee. This is to insure as far as practicable that there be factual reliability in the statements, that the material be presented with real regard to objectivity and without bias, and that the presentation be reasonably adequate from an educational standpoint.

"Putting Dairying on a War Footing" deals with some of the problems in the production and distribution of dairy products. The analysis here presented is not designed to guide producers and consumers in these current operations. In our society these operations are obviously to be conducted as these

individuals see fit within the framework of existing policies. However, individuals are interested in the effectiveness of current policies in achieving the objectives for which these policies are designed.

The Wartime Farm and Food Policy series, which included Pamphlet No. 5, was not an official publication series of the Agricultural Experiment Station. However, upon the appearance of the pamphlet it became evident that many readers assumed that it was a Station-sponsored publication. In view of this misunderstanding, it was agreed that the Agricultural Experiment Station should assume responsibility. It was further agreed that the author should be invited to prepare a revision which would follow the standard review procedures used with manuscripts for sponsored publications of the Station—procedures which had not been previously followed for pamphlets in this series.

The author, on the basis of the criticisms and suggestions concerning the first edition, has prepared a revision and enlargement. The analysis has been redirected toward further consideration of some of the developments which have occurred during the past year and with some forward look toward those which may be expected in the near future. In consequence, some of the points made in the previous analysis have been given added emphasis, some have been omitted, and new points have been included. Particularly has the author documented the discussion more fully. He has endeavored to show the pertinence of the survey of certain controversial items to the main purpose of the pamphlet. The manuscript was submitted to a committee of staff members of the Agricultural Experiment Station for review—the regular procedure for sponsored publications. It has been approved for publication. To the author and to the committee the thanks of the Agricultural Experiment Station are due for the patience and care used in preparation and review.

R. E. Buchanan,
DIRECTOR

SUMMARY[1]

This study is a review of prospective supplies and demands for dairy products in 1944 together with an appraisal of some of the national policies which could be followed in meeting the problems growing out of the dairy situation.

1. The amounts of dairy products required in 1944 for lend lease, for the military forces, and for feeding liberated countries, plus the quantities which consumers will be willing to purchase at ceiling prices, are expected to be considerably greater than the quantities produced. Demands for milk for all uses may aggregate 140 billion pounds or more. Milk production for all uses is expected to be about 115 billion pounds.

2. Although there have been and will be shortages of nearly all dairy products in some areas, supplies of butter, cheese, evaporated milk, and dried skim milk are likely to be proportionately furthest below demands.

3. Because of the high nutritive value and relatively low resource costs of whole milk and milk products utilizing jointly or separately all of the milk solids, efforts should be made to stimulate increased production of milk in areas where all of the milk solids can feasibly be made available for human consumption. Increased production of milk for such uses can be most easily encouraged by increasing the returns which farmers receive for whole milk. Ordinarily, such encouragement could be offered by increasing the prices for milk. However, given the existing economic and political framework within which the war economy is functioning, the payment of subsidies may offer a more practical alternative than would increased milk prices.

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[1] This project is based on studies carried on under Project 818 of the Agricultural Experiment Station, Iowa State College. These studies were aided by a grant from the Division of the Social Sciences of the Rockefeller Foundation, New York.

Acknowledgments of the professional contributions made by individuals appear at the end.

4. A net addition to the nation's food supply could be achieved at relatively low costs if larger quantities of the non-fat milk solids now being fed to livestock could be diverted into human consumption. The most feasible method for obtaining such food is through increasing the production of dried skim milk. Increased production of dried skim milk can be encouraged by:

a. Increasing the prices for dried skim milk or by paying subsidies to milk producers to increase their returns from selling whole milk rather than cream.

b. Paying subsidies to milk producers for adjusting their production methods and securing equipment so that they can produce whole milk acceptable for the manufacture of dried skim milk.

c. Indicating to farmers the ways in which the amounts of skim milk fed to livestock might be reduced.

5. Even though steps are taken to get additional milk produced for products utilizing all of the milk solids, and greater amounts of non-fat milk solids are diverted into human consumption, there will still be shortages of some dairy products. Additional butter could be provided without increasing the total output of milk or decreasing the total production of other dairy products if the fat content of butter was lowered or if the butterfat content of such products as fluid milk, evaporated and condensed milk, dried whole milk, and cheese was reduced and the butterfat thus extracted was diverted into butter. Another alternative which could also be employed to minimize any adverse effects of these expected shortages upon the general level of nutrition and morale is the provision of additional quantities of acceptable low-cost alternative foods.

6. The provision of satisfactory alternative foods to make up for shortages of fluid milk, cheese, evaporated milk, and dried milk probably would prove extremely difficult. Although various combinations of foods are satisfactory as nutritional substitutes, few are likely to be highly acceptable

in the diets of many consumers. Furnishing consumers with an alternative fat spread to make up for any shortage of butter may be less difficult. Although there are many fats which could be substituted for butter, the most generally acceptable fat spread now available is oleomargarine. The increasing reliance of our population upon such foods as bread, the complementarity with bread of fat spreads, and the possibility that consumers may prefer maintenance of the usual butterfat content in other dairy products rather than more butter are among the factors which bring up for critical re-examination the whole system of restrictions that have been placed upon the manufacture and sale of oleomargarine.

7. Equitable distribution of existing supplies of dairy products is necessary to maximizing both health and morale. Consumer rationing of butter, cheese, and evaporated milk in a group of foods including meats and fats and oils has been in effect for some time. Limitations on the quantities of fluid milk which might be sold have also been established in many of the larger cities. Such limitations have been invoked in many markets to divert milk away from fluid use and into manufactured dairy products. Unless all of the milk solids from the milk thus diverted are made available for human consumption, such limitations do not appear desirable.

8. Limiting fluid milk consumption by invoking limitations upon the sales of distributors is a procedure involving fewer administrative complexities than would point rationing. The general level of fluid milk consumption is relatively high in the areas where such limitations have been invoked. There have been few sizeable reductions in supplies to distribute among individual consumers.

However, if nationwide fluid milk rationing is undertaken or if large reductions in consumption are necessary in the areas where milk sales are now limited, rationing of milk in a manner similar to that by which meats, fats, and oils, and some other foods are rationed, is likely to prove most equitable. Fluid milk, fluid cream, and evaporated milk

could, under such circumstances, constitute a group of foods to be rationed by points.

9. Some of the postwar implications of wartime developments in the dairy industry are listed in the final section.

I. NATURE OF THE PROBLEM

This pamphlet is an analysis of some alternative solutions to problems arising because, during the war period, the available supplies of milk and dairy products will be less than the demands. Because of their importance in the human diet, careful study is desirable to analyze how best to put production, distribution, and consumption of dairy products on a war footing.

Milk is recognized as one of man's most useful and satisfactory foods. The nutritional value of milk rests on several bases. Its proteins are of high quality; it contains relatively large amounts of calcium as well as several of the other minerals essential to health; and it is also a source of many of the vitamins—vitamin A, riboflavin, and thiamin being present in relatively large quantities. Milk also contains fat and carbohydrate. These nutritive characteristics have given dairy products a prominent place in the seven groups of basic foods recommended by the United States Department of Agriculture as foods which should be included daily in the diet for the maintenance of optimal health and vigor.[1] Nutritionists suggest that wherever feasible each child should consume at least one quart of milk and each adult one pint of milk daily.

The war has emphasized the need for milk and its products. It is believed that few other foods contribute as much to both human nutrition and civilian morale. Important changes have occurred during the last three years in both the consumption and production of dairy products. About one-fifth of the total milk products (in terms of whole milk equivalent)

[1] The seven groups of basic foods, as recommended by the U. S. Department of Agriculture are: (1) green and yellow vegetables; (2) oranges, tomatoes, grapefruit; (3) potatoes and other vegetables and fruits; (4) milk and milk products; (5) meat, poultry, fish, or eggs; (6) bread, flour, and cereals; (7) butter and fortified oleomargarine.

has been going to the military agencies, lend-lease, and other non-civilian uses. It seems very likely that UNNRA[2] will draw upon the United States for milk and milk products. Civilian demands for dairy products have increased, primarily because of a substantial increase in per capita income. Studies of consumption patterns indicate that average individual consumption of most dairy products varies directly with per capita income. Civilian incomes available for expenditure on consumers' goods aggregated about 40 per cent greater in 1943 than in 1941.[3]

To meet certain problems arising from shortages[4] of dairy products, butter, cheese, and evaporated milk are being rationed to consumers. Sales of fluid milk and cream have been or are to be limited in many areas. Ice cream production has been curtailed, and the butterfat content of fluid cream has been limited to a maximum of 18 per cent. Special attempts are being made to maintain or expand the production of milk by such means as the payment of subsidies on milk and butterfat, deferment of farm workers from military service, and the provision of equipment and materials needed to increase the production of dried skim milk.

In spite of the various measures that have been adopted, shortages of dairy products are occurring frequently. There have been local shortages of fluid milk, particularly in industrial areas. Butter has not always been available to prospective buyers in consuming centers distant from the primary production areas. Many consumers have been unable to purchase cheddar and certain other types of cheese. Dried skim milk production has not kept pace with the demand. Total domestic milk production in 1943 was about 118 bil-

[2] United Nations Relief and Rehabilitation Authority.

[3] See *Survey of Current Business*, U. S. Dept. of Commerce, Bureau of Foreign and Domestic Commerce, December, 1943.

[4] The term "shortage" as used in this analysis refers to the difference between the aggregate amounts of a commodity which consumers are willing to take from the market at given prices and the amounts which are available for them to purchase at these prices. Consequently, as prices to consumers are increased a "shortage" may become smaller (there being no change in supplies, consumers' incomes or other prices), since the amounts which consumers are willing to buy vary inversely with price.

lion pounds.[5] This is estimated to be approximately 18 per cent short of the total amount which would have been taken from the market at prices prevailing during the year.

Consumer demand for various dairy products probably will continue at least as great and possibly greater during 1944 than in 1943. Military needs are likely to be as large or larger in 1944 than they were in 1943. Lend-lease requirements, coupled with demands of UNRRA for feeding the peoples of occupied countries, probably will exceed the amounts taken for these purposes during the past year. The demand for dairy products in the aggregate—non-civilian requirements plus the amounts which civilian consumers probably will wish to purchase at established prices—will be about as indicated in table 1.

TABLE 1

EXPECTED SUPPLIES AND DEMANDS FOR VARIOUS DAIRY PRODUCTS, 1944

Product	Expected Demand[a] (Millions of Lbs.)	Expected Supplies[b] (Millions of Lbs.)	Expected Deficit (Millions of Lbs.)
Fluid milk and cream (whole milk equivalent)	57,000	53,000	4,000
Butter	2,600	2,000	600
Cheese	1,400	980	420
Condensed and evaporated milk	4,000	3,300	700
Ice cream	7,000	5,000	2,000
Dried whole milk	130	130	0
Dried skim milk	1,100	525	575
All milk and milk products (Whole milk equivalent)	145,000	120,000	25,000

[a] These estimates of demands for dairy products at expected ceiling prices have been prepared by the author and are based upon past consumption patterns of civilians and military personnel plus expected demands for feeding liberated countries and for lend-lease. Civilian demands are estimated from data on per capita consumption of various products by consumers in various income classes in 1935–36, adjustments having been made for changes in the amount and distribution of income available for expenditure on food.

[b] Estimated from unpublished data prepared by the War Food Administration and the Bureau of Agricultural Economics, U. S. Department of Agriculture.

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[5] Statistics on production of milk and of various dairy products used throughout this analysis are based on data furnished by the Bureau of Agricultural Economics, U. S. Department of Agriculture, and the War Food Administration.

Official estimates indicate that milk production in 1944 for the nation as a whole probably will not exceed that of 1943 and may be about 4 billion pounds less than it was in 1942. (See table 2.) If this prediction is a reliable one, the difference between the estimated total demand for milk during 1944 and the amount which will be available to consumers

TABLE 2

MILK PRODUCTION ON FARMS IN THE UNITED STATES, 1935–44

Year	Total Production[a] (Billions of Pounds)	Production per Capita (Pounds)
1944 (expected)	115	841
1943	118	872
1942	119	888
1941	115	867
1940	111	844
1939	109	836
1938	107	827
1937	103	802
1936	103	807
1935	101	796

[a] Data are compiled from *Agricultural Statistics*, U. S. Department of Agriculture, 1941, table 579; 1942, table 600; and *The Dairy Situation*, U. S. Department of Agriculture, Sept., 1943.

will be about 30 billion pounds. (Refer to table 1.) The manner in which this deficit will be distributed among the various dairy products is extremely difficult to forecast, since it will depend primarily upon the various price and rationing policies which are followed.

Such policies are subject to change and cannot be accurately forecasted. However, it is likely that the gaps between expected demands and available supplies will be proportionately greatest for dried skim milk, cheese, ice cream, butter, and fluid cream (see table 1).

The magnitude of these prospective gaps between demands and supplies may appear to be disturbing. However, there are adjustments in production and consumption of milk and milk products which can minimize any adverse effects which such shortages may have upon the health or morale of consumers.

Any effective program designed to cope with this problem will have numerous and intricate ramifications. The adjustments are national in scope. Milk production is not confined to a homogeneous area. Production conditions between farms are often quite diverse. Thousands of dairy farmers, processors, and distributors would be affected by any action program to stimulate given production and consumption patterns; their acceptance and cooperation are essential if the program is to succeed. Furthermore, consumers' interests must also be considered. These conditions render a simple analysis extremely difficult.

The following pages present an analysis of various alternative courses of action which might be taken to encourage the kinds of production and consumption which appear most desirable, given the framework within which the nation's economic organization is likely to function during the war.

II. WARTIME ADJUSTMENTS IN THE OUTPUT OF DAIRY PRODUCTS

Adjustments which could be made in the production of dairy products fall essentially into two categories: (1) increasing the production of milk for all uses, and (2) shifting the use of the milk that is produced. Adjustments of the first kind would make it possible to increase the output of one or more products without reducing the output of other products. Making better use of the milk that is produced, however, involves a reallocation of the total milk supply or its components in terms of the proportions which go into the various products.

A. *Kinds of Adjustments Which Could Be Encouraged*

1. *Increasing Milk Production for All Uses*

a. *The physical limits to wartime increases in milk production.* The quantity of milk produced in any given year is the product of the number of cows milked and the average amount which each cow produces. Thus, milk production may be increased by increasing the number of cows milked or the average annual production per cow. But there are rather definite physical limits to the increases which might be obtained in 1944 in either the number of cows milked or average production per cow.

Increasing the cow population is normally a relatively slow process. About two years usually elapse from the time the heifer calf is dropped until she begins to produce milk. A large percentage of the heifers is required to maintain the cow population—to replace cows eliminated from production. Consequently, in 1944 the steps that can be taken to increase the number of cows milked are limited primarily to measures which will bring into production cows which would otherwise not be milked. For example, herds could be

less severely culled, thus maintaining some cows in production for a longer-than-normal period; or cows which are potentially lower-than-average producers and would otherwise be slaughtered, could be saved for milk production; or cows now being kept primarily for beef production could be milked. About 10 billion pounds of milk might be added to total production in 1944 if all cows able to produce 2,000 pounds or more a year, but which are not now in production, were milked.

By increasing the amounts of feed—particularly feed grains—fed to milk cows, production of milk might be increased as much as 25 per cent on some farms. Increases of this magnitude, however, would require very large increases in the grain consumption of dairy cows, and would not be possible on all farms even though the grain were available. An increase in milk production of 5 to 10 per cent (or 6 to 12 billion pounds) over 1943 is probably the maximum which could be expected from heavier feeding of existing cows.

b. *The desirability of attaining maximum milk output.* Through bringing more cows into production and feeding dairy cows at heavier rates, milk production could be increased considerably—possibly enough to satisfy expected demands for all dairy products in 1944.

Unlimited amounts of feed, labor, and materials, however, will not be available. Increased feed intake of cows would have to be primarily feed grains diverted from use by other kinds of livestock. Similarly, some of the additional labor that would be required to increase the output of dairy products is now being used in turning out other foods or war materials. An appraisal of the desirability of increasing milk production should take into consideration the relative efficiencies of producing given amounts of food nutrients by various alternative means. Comparisons should deal with (1) the relative efficiencies with which various kinds of livestock convert feed into food, and (2) the relative efficiencies with which various kinds of livestock convert labor into food.[6]

[6] Some data relating to these comparisons are presented in tables 1–10 in the Appendix.

As converters of feed into either total food energy or protein alone, dairy cows are highly efficient in comparison with other kinds of livestock. The efficiency of milk production is determined by the pattern of its utilization as human food. Dairy cows of average productivity or above whose output is consumed as whole milk rank highest in the efficiency of converting feed into protein and rank second only to hogs in converting feed into total food energy. Additional production of milk should be encouraged where humans can consume all of its essential ingredients.

If only the butterfat is used for human consumption and the skim milk is fed to hogs, the amount of *protein* made available for food from a given amount of feed is relatively low in comparison with that made available from some other kinds of livestock. The amount of *food energy* made available as food, however, is relatively large, falling below only that from hogs and that from dairy cows from which whole milk is utilized.[7] From a purely economic point of view it does not seem wise in times of food shortages, such as now confront the nation, to encourage a marked increase in the production of milk, if fat is the only portion of the milk solids to be used as food. Additions to the present supply of animal fats can be produced at lower feed costs if the additional feed required is fed to some other kinds of animals, particularly to hogs. Or it may be advisable to shift more land from growing feed to the production of oil-bearing seeds. In many cases, an acre of land will produce more fat if used for growing oil seed crops than if used for growing feeds for livestock.[8]

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[7] See tables 1 and 2 in the Appendix.

[8] Refer to appendix table 9 for some comparisons of fat yields per acre of land. These comparisons of relative efficiencies (see appendix for more complete analysis) can be used in estimating the changes required to effect particular changes in production, if one is discussing production shifts which are not so large that they would alter the average yields. If the production changes would involve, for example, reducing to zero or doubling the output of one of the major Corn Belt crops or livestock products, these comparisons would be meaningless. However, when the proportionate increases or decreases in production are relatively small, such comparisons can aid in estimating the changes in output which will result from such shifts.

The desirability for making shifts in crop acreages must be evaluated not only from the standpoint of relative current yields, but one must also consider

(*Continued on p. 15*)

The amounts of labor required to produce given amounts of food nutrients by various alternative means must also be considered in evaluating the desirability for producing more of one food or less of another. At least part of the labor used in producing such crops or kinds of livestock as are typical of the Corn Belt could be utilized in producing another of these kinds of crops or livestock.

As a converter of labor into protein, the average dairy cow is somewhat more efficient than any other kind of livestock. In terms of labor requirements per unit of food energy produced, dairy cows rank considerably below hogs. If the objective is minimum average labor requirements per unit of fat returned, then many plants (soybeans and flaxseed are examples) are more efficient sources than any of the animals.[9]

Care must be exercised in interpreting such comparisons of the relative efficiencies of kinds of livestock or crops, for these comparisons do not take into consideration costs of processing and marketing. Relative costs to consumers of nutrients secured from various alternative foods are dependent upon relative prices which consumers have to pay for these foods. Some comparisons of amounts of protein obtained from selected food sources are indicated in table 3.

It should be pointed out that efficiency in converting resources into food is but one of the determinants of the manner in which these resources should be used in maximizing their contribution to human welfare. Acceptability of the various foods in human dietaries must also be considered. People do not prefer to eat only foods which are "good for them." Food habits are exceedingly important in determining

(*Footnote 8—continued*)
future yields, i.e., the relative effects of various changes in crop acreages upon depletion or erosion of the soil. An increase in the acreage of soybeans accompanied by a corresponding reduction in the acreage of corn will not alter substantially the rate of soil depletion or erosion. An increase in the total acreage of intertilled crops, however, may speed depletion or erosion. In determining the extent to which the soil might economically be depleted or restored, one must compare the returns from such depletion with the costs of rebuilding the soil. Depletion of the soil during the war may be justifiable, considering the extent to which it may add to our effectiveness in winning the war and establishing a stable peace.

[9] See Appendix, table 9.

the acceptabilities and consequently the relative preferences for various foods. Civilian morale is closely related to the provision of foods which are most acceptable. Acceptability, however, is probably of more importance in determining the "best" allocation of resources during peace than in a period of war when the direction of production to maximize the war effort is of prime importance. In this section of the analysis relative acceptabilities of various foods are ignored. This factor will be considered in a subsequent section.

c. *How much should milk production be increased?* The preceding part of this analysis indicated that it would be desirable from a nutritive standpoint to encourage increases in milk production, providing all or most of the milk solids can be used as food.

Supplies of feed grains will be sufficient to permit expansion of milk production in 1944, if these feeds can be shifted from less efficient kinds of livestock. Little shift of grain to dairy cows, however, should be encouraged unless all or most of the ingredients in the additional milk are made available for human consumption.

If feed grains are to be used most efficiently by livestock in contributing to optimum human nutrition, they should be fed to the various kinds of livestock so that the production of needed food nutrients is at the maximum. This condition is achieved when the additional returns of these nutrients, resulting from feeding any kind of livestock an additional unit of grain, are just equal to the additional returns from feeding the same amount of grain to other kinds of livestock. For example, the output of food protein produced from a given amount of feed grain is maximized when feed is allocated so that the additional amount of protein (in the food product) produced from a pound of grain is the same regardless of the kind of livestock to which this grain is fed or the way in which the product is used.

In order to estimate accurately the extent to which milk production should be increased, one needs to know not only the relative rates of conversion of feed into food at various

rates of feeding, but also the levels at which dairy cows are being fed. Although it is known that successive equal increments of feed bring successively smaller increments of milk, adequate information relative to the levels at which farmers are now feeding is not available. Consequently, one can only indicate the general limits within which increased milk production should be encouraged. An increase of from 5 to 10 per cent over 1943 production is considered to be the maximum physical increase possible in 1944 from feeding existing cows at heavier rates. A somewhat smaller increase—perhaps from 3 to 5 per cent—is probably economically desirable.

2. *Improving the Pattern of Milk Utilization*

Increasing milk production is but one of the adjustments which can be made on the production side. Another adjustment which is perhaps of greater importance is improving the pattern of utilization of the milk that is produced. This may be achieved by diverting milk from one dairy product to another or by shifting into food a larger proportion of the non-fat milk solids now being fed to livestock.

a. *By diverting milk from one dairy product to another.* Whether more or less milk should be directed into a particular dairy product depends upon several factors some of which are: the relative nutritive values of various dairy products, their relative acceptabilities as foods, and their patterns of consumption.

During peacetime relative acceptabilities of various dairy products are expressed in terms of relative prices which people are willing to pay for given quantities of these products. These consumer prices are reflected in the prices which manufacturers can afford to pay for milk to be used in a given product. However, since we are operating under wartime price controls, food preferences of consumers cannot be fully reflected in the price structure. Furthermore, these preferences cannot be fully considered in determining the most desirable production pattern, since attempting to fulfill them often conflicts with maximum war production.

The consumption pattern of various dairy products is related to the nutritional well-being of various consumers. This pattern is related not only to the way in which the products are rationed, but also to the relative prices and preferences for various products and to the distribution of income. It seems very likely that only small changes in the amounts and kinds of food intakes would result from such alterations in the allocation of milk among the various products as could be attained under our given political and economic framework. Consumption patterns can be altered more effectively through rationing than by reallocation of the proportion of total milk production used in various products.

Some small rise in the national nutritional level might be possible by diverting some milk from one dairy product to another. However, we do not have sufficient information to determine accurately the "best" allocation of the milk that is produced. The most important gains can be attained by greater utilization as food of some of the milk solids now being fed to livestock.

b. *By increasing the total production of dried skim milk.* The total contribution to human nutrition of a given supply of milk could be increased to the extent that more separated milk, buttermilk, and whey may be made available directly as human food. Not all of it can be, of course. Some young animals must be fed milk. But at present considerable amounts of skim milk, buttermilk, and whey contribute much less to human nutrition as livestock feed than if they were consumed as food. It is easier to get more skim milk for human nutrition since its quantity is much greater than that of either whey or buttermilk. More than 35 billion pounds of skim milk were fed to livestock in 1943. Drying skim milk appears to be the most feasible method for making larger quantities of the non-fat solids available for food.

At prices now prevailing, dried skim milk provides essential nutrients, particularly proteins, at a much lower cost to consumers than do poultry, meat, fluid milk, or eggs. The

costs to consumers of selected animal proteins are indicated in table 3.

Demands for dried skim milk have risen markedly during the war. In 1938 less than 300 million pounds were manufactured for human food.[10] Dried skim milk had a small

TABLE 3

RELATIVE NET COSTS[a] OF PROTEIN PROVIDED TO CONSUMERS FROM SELECTED ANIMAL PRODUCTS

Product	Price of Product[b] (Per Pound)	Approximate Price of Protein[a] (Per Pound)
Dried skim milk	19 cents[c]	$0.46
	(25 cents)[d]	0.61
Fluid milk	15.2 cents (per quart)	1.32
Round steak	41.8 cents	2.30
Pork chops	37.6 cents	2.57
Roasting chickens	44.7 cents	2.75
Lamb chops	45.7 cents	3.80
Eggs	63.9 cents (per doz.)	3.83

[a] The fat in the foods other than fluid milk and eggs is valued at 18.8c per lb. (the current average retail value of lard). The butterfat in fluid milk is valued at 50c per lb., and the milk sugar at 6.8c per lb. (the current average retail price for sugar). The cost of the protein is thus the cost of the product minus the value of the fat and milk sugar. The other nutrients are assigned no value.

[b] These are average prices for these foods in 56 cities as listed by the Bureau of Labor Statistics for December 14, 1943. See *Monthly Labor Review*, U. S. Department of Labor, Bureau of Labor Statistics, Vol. 58, No. 2 (February, 1944), pp. 413–14.

[c] Not listed at retail. This is the estimated retail price given current (February, 1944) prices at drying plants.

[d] Approximate price at which dried skim milk might sell at retail if price at the drying plant was 20 cents per lb.

market, prices for the product were low, and creameries were able to pay farmers only a low price for skim milk. In 1943, production of dried skim milk was about 480 million pounds. Estimated over-all needs for dried skim milk for human food had risen to more than 1.1 billion pounds. Much of this estimated requirement was to have gone to lend-lease and to people in liberated countries. But more than one-half of it would have been used domestically—much of it in bread. The addition of dried skim milk to bread provides a means

[10] *Agricultural Statistics*, 1940, table 580, page 436. U. S. Department of Agriculture.

for distributing important nutrients widely among the population—even better than might be accomplished through increased consumption of fluid milk. Many nutrition workers have recommended improvement of diets by the addition of 6 per cent milk solids to bread. In January, 1943, the Food Distribution Administration issued an order that effective July 1, all bread containing milk should include not less than 3 per cent dried milk solids. The supply of dried skim milk available, however, was far from sufficient to permit enforcement of this ruling, and it was rescinded.

In spite of its efficiency as a food and the new demands for the product, the production of dried skim milk for human food was nearly one-fourth lower in 1943 than it was in 1942. Production in 1944 is expected to be about 525 million pounds, or about 10 per cent more than that of 1943. Some of the factors responsible for the lower production in 1943 were: (1) prices for dried skim milk were not sufficiently high to encourage farmers to sell whole milk rather than cream; (2) farmers were not fully aware of the possibilities for substituting in livestock rations other feeds for part of the skim milk which might have been diverted to human food; (3) many farmers were unable to get as much protein supplements as they wanted and held back their skim milk for livestock feed; and (4) less milk was available for drying than was expected because it was diverted for use as fluid milk.

c. *By diverting butterfat from other dairy products to butter.* One alternative procedure for obtaining additional quantities of butter without increasing total milk production or reducing the output of other dairy products is to lower the butterfat content of such dairy products as fluid milk, evaporated and condensed milk, dried whole milk, fluid cream, and cheese, and diverting the fat thus extracted into butter. In Germany during the war, the butterfat content of fluid milk has been lowered to 2.5 per cent.[11] The War Food Administration has issued an order limiting, as a wartime measure, the butterfat

[11] See Karl Brandt, "Fats and Oils in the War," *War-Peace Pamphlet* No. 2, Food Research Institute, Stanford University, June, 1943, page 15.

content of fluid cream and ice cream. This butterfat conservation order has been in effect for more than a year. Consequently, many dairy products distributors and the War Food Administration have already had some experience in working with such a limitation order.

About 53 billion pounds (whole milk equivalent) of fluid milk and cream is expected to be consumed in the United States in 1944. Approximately 9.5 billion pounds of milk will be used to produce cheese, and more than 8 billion pounds of milk will be evaporated, condensed, or dried. Butterfat from all of this milk could not be diverted into butter. Since the butterfat content of fluid cream has already been reduced, it may not be feasible to encourage any further reduction. About one-fifth of the fluid milk and cream is consumed on farms. Butterfat from this milk would be difficult to divert into butter. Some of the fluid milk not consumed on farms is sold by producer-distributors who have inadequate facilities for standardizing the milk. Part of the butterfat from a maximum of 50 billion pounds of milk might be diverted into butter. If the butterfat content of 50 billion pounds of milk used in various dairy products including fluid milk, was reduced from about 4 per cent to 3 per cent, and this butterfat was diverted into butter, an additional 625 million pounds of butter could be manufactured.

The effect of such a change on the acceptability of the products to the consumer is difficult to estimate. All consumers may not prefer to have more butter if this means less butterfat in some other dairy products. Where such changes have occurred in fluid cream and ice cream, however, few serious objections have been registered.

Difficulties to invoking this procedure may be posed by the various state and federal laws establishing minimum butterfat contents for some products. These would have to be set aside during the war or new laws would need to be enacted. Since the butterfat content of some dairy products, particularly fluid milk, has been a competitive selling point, distributors may be reluctant to reduce the percentage of butter-

fat in their products. Such resistance would be greatest in markets where all distributors could not, because of the inadequacy of their facilities, reduce the amount of butterfat in the milk which they distribute. Some dairy breed associations have used as an important selling point the high fat content of the milk from cows of their breeds. Where different products compete to some extent with each other, as do evaporated milk and fluid milk, reductions in the fat contents of both products would probably be desirable in order to prevent giving one product an additional competitive advantage.

One means for encouraging fluid milk distributors to accept this diversion of butterfat from fluid milk to butter would be to reduce the price ceilings on fluid milk by a smaller amount than the returns from the sale of the butterfat. Whether such a means should be employed is in part dependent upon the adequacy of existing margins, and upon consumers' acceptance of this procedure.

Butter supplies also could be increased by reducing the fat content of butter. This is essentially the result of the use of butter extenders in households. The possibility for employing this procedure as well as diverting butterfat from other products to butter makes somewhat more complicated the determination of the most desirable of alternative procedures for increasing butter output from a given total supply of milk. Manufacturers and distributors of various dairy products may sanction the general procedure only if reductions are made in the fat contents of all of the products where such reductions are feasible.

B. *Means for Encouraging Desirable Adjustments*

The means for suitable and practical adjustments in milk production and utilization are of two types: measures which seem to be desirable if there is to be encouragement of an appropriate production pattern, and the measures which are needed to improve the utilization of the milk which is produced.

1. *Measures Needed to Encourage the Desired Production Pattern*

Increased production of milk to be used as fluid milk or in products utilizing all of the essential milk solids is desirable from a nutritional standpoint. If these alterations in the milk production pattern are to be encouraged, the incentives prompting farmers to produce milk from which all of the milk solids are to be directly consumed in food should be made more attractive. Three such possible factors which should be analyzed are increased prices for milk, the subsidizing of milk production, and modification of sanitary standards.

a. *Prices for milk.* One of the most direct and impersonal means for encouraging the direction of more feed and labor into the production of more milk is to increase prices for milk relative to the prices of the other products which could be produced from the feed and labor. The price pattern for livestock products should be established so as to encourage the output of milk for fluid use or for use in products which jointly or separately make available for human consumption all the milk solids. And the price relationships among dairy products should induce farmers now selling only cream to shift to selling whole milk wherever this shift is feasible.[12]

[12] The relationship of the price of one product to that of another is the important element in determining the way in which resources are allocated among the various alternative lines of production. Thus, maladjustments in price relationships may be corrected either by increasing the prices of the products whose prices are too low or by decreasing those prices that are too high.

In the butter areas the spread between butterfat and whole milk prices is too low to encourage a marked shift to whole milk sales. Whole milk prices are somewhat low relative to the prices of most other animal products, particularly hogs. Increasing whole milk prices would establish a better balance between whole milk and butterfat and between whole milk and other livestock products. The increase which would be desirable in order to establish the best balance between whole milk and other livestock products is probably too small to bring about a large enough differential between returns from selling whole milk and returns from selling cream—because of the relatively low spread between current prices for these two products.

If whole milk prices in the west north central states were $3.25 per cwt.—a price about 35 cents per cwt. above the average dealers' buying prices in October, 1943—and butterfat was about 52 cents per pound (the average for October, 1943), farmers selling whole milk would receive $1.29 per cwt. (FOB country station) more if they sold whole milk of 3.8 per cent butterfat than they would receive if they sold only the cream. This would mean an average differential of

(*Continued on p. 24*)

Farmers might also be effectively induced to shift to selling whole milk if they are assured that the market will be supported during the war and early postwar period.

Although the pattern of relative prices is an effective guide to production, there are rather distinct limits to the way in which prices can be altered within the present political and economic framework. It is generally acknowledged that few, if any, prices can be reduced, because of political pressures and because of certain minimums imposed in establishing price ceilings. For example, the Second Price Control Act (October, 1942) established the minimum level of a ceiling on virtually any farm product at 100 per cent of parity. Price ceilings on farm products must also take into consideration the increases in costs of production which have occurred since January, 1941. On the other hand, the various "hold-the-line" orders which have been given to OPA by Congress and by the administration, combined with the way in which prices tend to be bound together, make difficult altering relative prices by increasing any price. For example, if one farm price ceiling is increased, this increase may raise the parity prices of other farm products and necessitate an upward revision in their ceilings. Furthermore, an increase in the price of such a commodity as milk would result in an increase in the cost of living and open the way for increased wages.

The significance of this situation—few prices can be reduced because of political pressures and legislatively and administratively established parities, and few prices can be increased because of the repercussions upon other prices and the conse-

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(Footnote 12—Continued)
$1.16 per cwt. at the farm. In order to increase the differential, either milk prices could be increased or butterfat prices reduced. Assuming that farmers are feeding their dairy cows at the most profitable levels and that they adjust their operations as milk prices change, an increase in whole milk prices of more than 50 cents per cwt. probably would encourage farmers to go too far (in terms of the alternative food returns which could be secured if the feed concentrates were fed to hogs to be marketed at 210 pounds), toward increased feeding of cows now being milked or those which could be economically shifted into production. Consequently, a greater increase in milk prices would be undesirable. Some reduction in butterfat prices probably would not discourage butter production in the areas where the resources have no more effective alternative uses, and would enable the differential to be widened.

quent breaking of the line against inflation—should not be underestimated. It means that unless the parity principles are abandoned or the line is allowed to be broken, the price pattern cannot be as effectively used to direct production as it could be in peacetime. It means that we may have to rely more upon other incentives in order to alter the pattern of production to more nearly meet our changing needs.

b. *Subsidizing milk production.* Paying subsidies to producers, like changing the pattern of relative prices, is a means for altering the production pattern. For example, paying to farmers a 50-cent subsidy on each hundred pounds of milk sold would offer to milk producers approximately the same incentive to increase their production of milk as would be offered by an increase in milk prices of 50 cents per cwt. When it is not expedient to alter the price pattern in order to induce shifts in production, subsidies may be used to supplement prices in bringing about the desired kinds of production. In some situations shifts in production might be achieved with smaller transfers of income if subsidies were used to encourage these shifts than if relative prices were changed. For example, changes in production may be feasible only in certain areas. The payment of subsidies may be restricted to such areas.

Nearly all of the subsidies which were granted during 1943 in connection with the production and processing of food have been to help maintain retail price ceilings. Because of its probable repercussion upon other prices and particularly upon wages, the puncturing of a few retail price ceilings may endanger the entire price control program. By granting to producers or processors a subsidy, rather than allowing them increased prices for their products, retail prices may be kept from advancing even though farm returns to producers are raised to cover increased production costs.

In several cities subsidies were paid to milk distributors for a short period during the winter of 1942–43 in order to enable them to pay higher prices to farmers without advancing the prices charged to consumers and at the same time maintaining distribution margins. These subsidies aroused much

criticism and were discontinued early in 1943. Since December 1, 1942, the Commodity Credit Corporation has been supplying funds for the payment of a subsidy of 3¾ cents per pound of cheese to the manufacturers. Beginning on July 1, 1943, butter prices were reduced through a subsidy of 5 cents per pound paid to creameries. Butterfat prices were not changed as a result of this procedure. Currently, subsidies are being paid to farmers selling either whole milk or cream. Rates of payment as of January, 1944, varied from 35 to 50 cents per hundred pounds of whole milk and from 5 to 6 cents per pound of butterfat sold, depending upon the area in which the producer was located. The rates of payment are generally lowest in the north central states where feed costs have advanced the least.

Although this subsidy program now in effect has many commendable features, payment of a subsidy when only the butterfat goes into human consumption does not seem warranted from an economic standpoint. It is desirable, nutritionally, to encourage increases in milk production so that insofar as practicable the milk solids from the increased production are directed into human consumption. If the subsidy is to increase significantly the yield of milk used in its entirety, subsidy payments should contribute to making markedly larger farmers' returns where whole milk is sold than where only butterfat is marketed. For the most part, an increased return for butterfat would not be necessary to maintain its production in areas where the feed fed to dairy cows cannot be fed to hogs or poultry or where the labor and land have no more important alternative uses.

An expansion in milk supplies suitable in quality for fluid milk, evaporated milk, cheese, or dried skim milk probably will require some changes in milk production methods in butter-producing areas. Although a high price for whole milk, relative to the returns from cream, will be necessary to induce farmers to shift to selling whole milk, a more rapid shift might be accomplished if payments to farmers also were made to encourage equipping their farms for improved han-

dling of their milk. This might be of particular importance to farmers in the Corn Belt where sizeable outlays for alterations in equipment may be required on some farms. Payments need not be offered to farmers already producing acceptable whole milk, and the payments might be non-recurring. They might be offered for a certain period of time, for once the necessary changes in production methods and facilities have been secured, further incentives of this nature will not be needed.

c. *Modification of sanitary standards.*[13] The various sanitary standards and codes established for milk are of importance not only because of their effect upon net returns to farmers and consequently upon the volume of milk production, but also because of their influence upon the way in which milk is utilized. Whether additional milk can be directed into products making use of all or most of the milk solids depends to some extent upon the sanitary standards which are established for fluid milk and the standards required by various plants for milk used in the production of dairy products.

Milk is very perishable and requires special care in its production, processing, and distribution to minimize deterioration of the various foods made from it. Dairy cattle, like other farm animals, are subject to certain diseases. Milk must also be handled by individuals subject to diseases. Consequently, it is obvious that for the protection of health and for the maintenance of satisfactory quality, there must be adequate provisions—perhaps both penalties and premiums—to insure the production of acceptable milk.

In order to adequately protect health, these provisions must include herd inspection and reasonable inspection and approval of the premises upon which milk is produced. Provisions to safeguard health should apply to all milk for food, whether it is to be consumed as fluid milk or as any of the foods made from it.

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[13] The term standards as discussed here refers to standards relating to prevention of the spread of disease as well as to the control of "quality" as it relates to the taste and keeping qualities of the product.

Whether milk is satisfactory from the standpoint of quality, exclusive of the disease aspects, depends upon the way in which the milk is used. This aspect of the acceptability of milk probably can be determined largely by minimum requirements for numbers of bacteria, acidity, foreign matter, and odors in the milk—requirements which may vary with the way in which the milk is to be used.

There are two principal aspects of existing sanitary codes relating to fluid milk which warrant re-examination during the present emergency. If certain items in existing codes are not essential to the protection of health or the maintenance of quality, and if these provisions impede the diversion of a larger proportion of the total milk solids into human consumption, they should be eliminated. Re-examination should be focused upon the lack of uniformity of standards, and upon provisions of little significance in safeguarding health which at the same time make difficult the entry of new producers into a given fluid milk market.

Many urban ordinances and state regulations establishing standards for fluid milk production and distribution have been formulated by local or state agencies at times when the shifting of supplies was considered to be of relatively little importance. Although these diverse standards may be adequate for the protection of consumers' health, their lack of uniformity—and particularly the lack of inter-acceptance of inspection and certification—makes the interchange of milk supplies between milk sheds difficult. The local shortages of fluid milk which have arisen during the war have brought this condition to the foreground and have led to some modifications of these restrictions. It has been necessary to ship milk for greater distances. Distributors have been confronted with the problems created by differences in sanitary codes. There has been some tendency toward unification of standards to facilitate necessary shifts of milk from one milk shed to another. For example, there has been increased adoption of the U. S. Public Health Service Standard Ordinance. Further unification, however, if the uniform standards adopted can be

reasonably met by producers and are at the same time adequate in protecting health, would be desirable in order to make less difficult supplementing milk supplies in one market with supplies from other areas.

Undoubtedly in some instances requirements have been inserted into sanitary codes deliberately to restrict entry of new producers into a market. Such special items frequently have no direct relationship to the protection of the consumer's health.[14] In order to assure adequate milk at reasonable cost to consumers, careful study needs constantly to be given to the reduction of costs of milk production. Items in sanitary codes causing unnecessary expense to milk producers should be eliminated. Care needs always to be used to see that the standards are, on the one hand, adequate to protect consumers' health and, on the other, to hold costs of production to a minimum.

To maintain reasonable sanitation, routine tests and inspection of cows and production facilities are necessary and should be made periodically. They are and should be required by sanitary codes. Care should be used, however, to see that the requirements for equipment and the care of the dairy herd are germane to the production of acceptable milk. If not, the requirements should be reformulated. Particularly it is necessary to insist that inspection fees should be reasonable, and all producers willing to pay the fee should be granted inspection. There should be no development of trade barriers to interfere with the free movement and sale of fluid milk and dairy products. Many cities and states will not accept inspections made by any other than their own agencies. Provision should be made for recognition by all agencies of in-

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[14] Consult, for example, G. R. Taylor, *et al.*, *Barriers to Internal Trade in Farm Products*, Special Report to the Secretary of Agriculture, 1939.

Margaret G. Reid, *Food for People*, John Wiley and Sons, Inc., New York, 1943, Chap. 24, pp. 477–79.

I. W. Silverman, *et al.*, "Control by Licensing Other Entry into the Market," *Law and Contemporary Problems*, Spring, 1941.

Consumers' Guide, March, 1941, page 12.

Sale and Distribution of Milk Products, Connecticut and Philadelphia Milk Sheds, 74th. Congress, 1st Session, House Document 152, 1935, page 90.

F. V. Waugh, "Interstate Trade Barriers: A Proposal," *The Agricultural Situation*, February, 1941.

spections and examinations properly made by other accredited agencies.

2. *Measures Needed to Encourage Improved Utilization of the Milk Produced*

As was indicated previously in this study, the most important step which can be taken toward improving the utilization of the milk produced is to direct into human consumption as much as is feasible of the non-fat milk solids that would otherwise be fed to livestock. Some of the measures which might be taken to encourage such diversion are: (1) increased prices for dried skim milk, (2) the reduction in the amount of skim milk used as a feed for livestock, and (3) provision of adequate facilities for drying skim milk. These measures are analyzed in the following discussion.

a. *Increased prices for dried skim milk.* One step which would markedly contribute toward making additional non-fat milk solids available for human consumption would be to increase the prices paid to farmers for milk to be converted into dried skim milk. This is necessary to induce farmers to produce milk suitable for drying and to encourage the sale of whole milk rather than cream. With the present difficulties in securing protein feeds, many farmers are placing a value on the skim milk as animal feed higher than the returns from its sale. Furthermore, additional care and facilities may be required on some farms if whole milk acceptable for use in dried skim milk is produced. Farmers will need to be compensated for the additional costs incurred.

The solution to this pricing problem, however, is not as simple as merely increasing the prices for dried skim milk. It is the differential between returns from selling whole milk and returns from selling cream that induces farmers to sell one product or the other. This differential could be widened by increasing dried skim milk prices and holding butterfat prices constant, or by reducing butterfat prices and holding dried skim milk prices constant. If dried skim milk prices were increased and there were no changes in the prices of other

dairy products competing with butter plus dried skim milk for the whole milk, considerable diversion of milk away from evaporated milk and cheese plants would probably occur. Consequently, the prices for evaporated milk, cheese, and perhaps fluid milk would have to be increased in order to prevent such diversion, or butterfat prices would have to be decreased. The Federal Government has, however, committed itself to a policy of maintaining butterfat prices at about prevailing levels, and to "holding the line" against advances in food prices. Thus, dried skim milk prices are narrowly straightjacketed.

b. *Reduction of skim milk as a feed for livestock.* Separated milk is an important component of livestock rations—particularly those of calves, pigs, and poultry. Getting more of the non-fat milk solids into human consumption will mean that less skim milk will be available for livestock feeding. This is of special significance in the north central states where the bulk of the increase in dried skim milk production is likely to be secured. In order to induce farmers who rely almost entirely upon skim milk as a feed for young animals to sell whole milk rather than cream, not only should the differential in the returns from selling these two products be widened, but these farmers might also be shown ways of substituting other feeds for part of their skim milk.

It should be recognized that it would be impractical to divert into human consumption all the skim milk which is now fed to livestock. If, during the war, one-quarter to one-third of the amount of skim milk usually fed to livestock in peacetime were dried for food, the estimated demands for dried skim milk could be satisfied.[15] This is perhaps the most

[15] Estimates of dried skim milk production depend upon the assumptions which are made regarding relative prices for the various dairy products, the concentration of production, and the numerous other factors affecting the supply of milk available for drying. The estimate of one-quarter to one-third of the skim milk now fed to livestock (the equivalent of from 900 million to 1.3 billion pounds of dried skim milk) as being feasibly diverted into human food during the war disregards all of these factors except the density of milk production. It is based on the assumption that drying facilities are installed and operated in counties where at least one million pounds of butterfat were delivered by farmers as cream in the year 1939. This limits the major area where production would be increased to Iowa, Minnesota, Wisconsin, and scattered sections in some of the other north central states.

that can be expected, even though necessary changes in the price pattern are accomplished. If a shift of this magnitude were realized, a large volume of separated milk still would be available as livestock feed.

c. *Provision of facilities for increased production of dried skim milk.* Although in 1943 there was no widespread overloading of existing facilities for drying separated milk, additional facilities would be necessary if dried skim milk production were increased to 1.1 billion pounds in 1944. To some extent existing facilities could be more fully utilized. It might be possible to move driers and other equipment necessary to dry skim milk from areas where milk supplies are such that the equipment is only partially utilized to areas where supplies are large enough to permit fuller operation. Facilities for drying skim milk have been given high priorities in the allocation of strategic materials.

In addition to the equipment required to conduct drying operations, there is also the problem of providing equipment for transporting the milk from farms to creameries or other drying establishments. Additional milk cans would be needed. However, whether additional trucks to haul the milk would be necessary depends upon the way in which the collection problem is handled. It is very likely that, with reorganization of the collection of milk and cream to eliminate duplication of service and assure capacity loads for each truck now in service, few additional trucks would be required.[16]

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[16] Adequate presentation of the problem of reorganizing milk and cream collection would require more detailed analysis than can be presented here. Some studies, however, have been made indicating the extent to which there is duplication in service and the economies which might be effected by reorganization. For example, see:

Transportation of New Hampshire Milk, Bul. 325, June, 1940; II. *Reorganization of Truck Routes*, Alan MacLeod, N. H. Agr. Exp. Sta., Univ. of N. H., Durham, N. H.

Efficiency of Milk Marketing in Connecticut: 2. *The Transportation of Milk*, Bul. 328, D. O. Hammerberg and W. G. Sullivan; 3. *Economics of the Assembly of Milk*, R. G. Bressler, Jr., and D. O. Hammerberg, Bul. 239, Feb., 1942, Storrs Agr. Exp. Sta., U. of Conn., Storrs, Conn.

Cooperative Reorganization of Milk and Cream Hauling, Louis F. Herrmann, Paul E. Quintus, Wm. C. Welden, Misc. Report No. 53 (mimeo.), May, 1942, Coop. Res. and Service Division, F.C.A., Washington, D. C.

Possible Savings in the Assembly of Milk: A study of County Hauling in Northern Vermont, Alan MacLeod, W. E. Carpenter, and J. A. Hitchcock, B.A.E., U.S.D.A., New England Research Council on Marketing and Food Supply and Vt. Agr. Exp. Sta. cooperating, Washington, D. C., Nov., 1942.

III. WARTIME ADJUSTMENTS IN CONSUMPTION OF DAIRY PRODUCTS

Even though milk production is expanded in 1944, thereby increasing the supply of total milk solids, and additional non-fat milk solids are diverted from livestock into human consumption, there still will be sizeable gaps between the available supplies of some dairy products and the amounts which consumers would be willing to purchase at expected prices. The effects of such shortages can be partially minimized by adjustments in distribution and consumption. Among these adjustments is the provision of alternative foods and the establishment of means for equitably distributing the supplies that are available.

A. *Other Foods as Alternatives for Dairy Products*

Temporary civilian food shortages make it impossible for consumers to maintain some of their customary peacetime food habits. Reductions in the available amounts of a number of commodities, inevitable in a nation at war, tend to lower civilian morale. Rationing is a means for sharing these reductions. If, in addition to rationing, alternative goods are made available, consumer morale may be maintained at a higher level than it would be if no such alternatives were provided. Obviously, these alternatives should not require more resources for their production than would be required to produce the original goods.

1. *Alternatives for Milk and Cheese*

No other single food can adequately replace milk in the national dietary. Few consumers, with the exception of infants, however, depend upon milk as their sole food. The average diet consists of a variety of foods. Among the aggregate of foods ordinarily consumed are numerous partial alternates for milk. When consumed in proper combinations these may compensate for a reduction in the intake of milk. How-

ever, the inclusion of milk more than any other single food will improve the nutritional quality of the average diet.

As has already been noted, milk contains high quality proteins, fat, vitamins, and minerals that are of special significance in the diet. In view of possible decreases in the supply of milk and other whole milk products, it becomes important to consider foods that may serve as alternatives for them. Eggs, poultry, fish, soybean flour, vegetable soybeans, dried yeast, oatmeal, and the cereal embryos are sources of good quality protein. Peanuts, dried peas, and beans, if used in conjunction with other proteins, may make contributions toward balancing the protein portion of the wartime dietary. The proteins of milk, however, are not only of importance in themselves but are extremely effective in supplementing the proteins of cereals and legumes.

In general, American diets which include no milk furnish inadequate amounts of calcium and riboflavin and may often be deficient in protein. There is no other single food which will supply calcium as generously and in as equally utilizable form as milk. This is one of the reasons for curtailing supplies of milk for children only as a last emergency measure.

The riboflavin needs of the human being can be met by diets containing no milk. The average American consumer is not likely to make the necessary dietary changes, however, when milk is not available. Among the foods that are rich sources of riboflavin are glandular tissues such as liver, kidney, heart, and tongue; whole grain cereals, lima beans, and soybeans; and eggs, poultry, and fish. Supplies of all of these foods cannot be easily expanded. Whenever possible, however, increased use of these foods will help to compensate for any shortage of riboflavin. These foods and fresh fruits and vegetables are also good sources of thiamin. They may be used to help make up deficiencies in thiamin resulting from small reductions in the quantity of milk in the diet.

The above examples indicate some of the kinds of replacements which may be made in diets in order to compensate for reductions in the intake of milk or whole milk products.

Any broad recommendation designed to cope with shortages of a particular group of foods should take into consideration food habits and food preferences as well as nutritive values. For example, when milk is not available, many consumers may shift to coffee, tea, or soft drinks. These beverages obviously cannot be classified as satisfactory nutritive alternates for milk.

Where evaporated milk and dried skim milk are used in cooking, the provision of acceptable alternatives might prove somewhat easier. Satisfactory substitutes for cheese are likely to be difficult to provide, when one considers relative nutritional values as well as food habits.

Thus, with few exceptions it is impossible to provide single foods in practical quantities which will serve as nutritionally suitable alternatives for fluid milk, evaporated and condensed milk, dried milk products, and cheese. As has been indicated, however, partial substitutes are available which, when properly combined, will minimize the adverse effects of shortages of these dairy products during the war.

2. *Alternatives for Butter*

Supplies of butter for civilian consumption in 1944 are expected to be about 12 pounds per capita as compared to the average yearly amount of 17 pounds consumed during the period 1935–39. Butter is of nutritional importance chiefly as a source of food energy, fatty acids, and vitamin A. Whether fats in general have other functions in the diet beyond the provision of calories and the essential fatty acids is not entirely clear at the present time. In view of our relatively large average per-capita fat intake,[17] however, the reduction in fat consumption due solely to this reduction in butter supplies is likely to have little adverse effect upon the health of most American consumers.

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[17] Average annual per-capita fat consumption in the United States in 1943 is estimated to have been approximately 110 pounds. This includes the "invisible" (fats in meats, fish, milk, vegetables, etc.) as well as the "visible" (fats in such foods as lard, butter, vegetable compounds, margarine, etc.) consumption.

In many diets butter is an important source of vitamin A. With an average annual butter consumption of 17 pounds per capita, about one-eighth of the average requirement for vitamin A is supplied by butter. A reduction in the average per capita butter consumption of 5 pounds per year would represent a reduction of approximately only 4 per cent in average vitamin A intake, even though there were no compensating increase in the consumption of other foods containing vitamin A.[18] The Bureau of Human Nutrition and Home Economics of the Agricultural Research Administration estimates that the average daily intake of vitamin A in 1942 was 6,300 International units per capita.[19] This is about 25 per cent in excess of the average requirement. Consequently, it seems unlikely that average vitamin A intake will fall below the average recommended allowance, even though butter consumption is reduced.

It seems highly probable that the reduction in butter supplies will have few adverse effects upon human health, if there are no other changes in consumption. Consequently, from a purely nutritive standpoint no alternative fat spreads would need to be made available, if every consumer obtained the average butter ration together with average quantities of other foods containing fats and vitamin A.

Fat spreads, however, are complementary with bread. Since consumers may be urged to increase their cereal consumption in view of some reductions in supplies of animal products, and since bread is the main form in which Americans

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[18] The average daily allowance for vitamin A recommended by the National Research Council is 5,000 International units, an annual allowance of 1,825,000 International units. Assuming an annual butter consumption of 17 lbs. (the average per capita consumption for the years 1935–39), a consumer's intake of vitamin A from butter would be 229,500 International units with a vitamin A content of butter averaging 13,500 units—a figure suggested by recent assays. Thus, of the total annual vitamin A allowance, butter would supply about 12.5 per cent. The expected supplies of butter for civilians in 1944 will be about 70 per cent of the average yearly supplies for 1935–39. If there were no compensating increases in the consumption of other foods, this would mean a reduction of 4 per cent in vitamin A intake, assuming each consumer's intake was equal to the recommended daily allowance.

[19] See Raymond P. Christenson, *Using Resources to Meet Food Needs*, U. S. Department of Agriculture, Bureau of Agricultural Economics, May, 1943, table 2, page 10.

consume cereals, maintaining or increasing our supplies of fat spreads takes on added importance. Furthermore, butter was mentioned most frequently among those commodities whose shortages were most noticed by consumers interviewed in a recent survey.[20]

Important alternative courses of action which might be pursued in adjusting to the expected butter shortage are: (1) the production of additional milk the butterfat from which can be used in butter, (2) reduction in the fat content of butter and/or diversion of butterfat from other dairy products into butter, and (3) the provision of alternative fats or spreads for bread to supplement supplies of butter. These alternative courses of action are not mutually exclusive. All might be pursued simultaneously. The desirability for employing any of them depends upon their relative costs and the extent to which they meet consumers' preferences. It has been pointed out in a previous section that, from a nutritive standpoint, it is not desirable—given our limited resources and the alternative ways in which they might be employed—to produce enough additional milk to provide sufficient butterfat to satisfy all demands for butter. Whether butterfat should be diverted from other dairy products to butter depends upon relative consumer preferences for additional butter, for dairy products containing the usual amounts of butterfat, and for foods which could be used as alternatives for butter, and upon the legal and administrative difficulties encountered in distributing the incidence of such diversion. This procedure is relatively inexpensive in terms of the amounts of additional resources required to put it into operation. However, making alternatives for butter more readily available would probably reduce the extent to which butterfat would have to be diverted

[20] A survey recently conducted under the supervision of George Gallup, Elmo Roper, Crosley Inc., and research men of Harvard Business School, Princeton University, Life Magazine, Columbia University, the Office of Survey Standards, and the Bureau of the Budget indicates that butter was most frequently mentioned by interviewees in response to the question, "What are some of the shortages that have bothered you most?" A total of 4,935 interviews were made. Butter was mentioned by about 9.9 per cent of the interviewees. Refer to *Indices*, the Research Division, Meredith Publishing Co., Des Moines, Iowa, Vol. XVI, No. 2 (Jan. 15, 1944) page 9.

from other products into butter in order to reasonably satisfy consumers' demands for spreads for bread.

There are a number of acceptable replacements for butter as it is used in cooking. Only a few fats, however, are used as spreads for bread. Among these are oleomargarine, vegetable shortening, lard, salad oil, peanut butter, and cream cheese. The non-fat spreads for bread are primarily limited to jams, jellies, etc. These are used both as an alternative to butter and in conjunction with it. Butter extenders are also a means for adding to the supplies for spreads for bread.

The production of some of these spreads has increased during the war, while the amounts of others available to civilians have been reduced. Although data are not complete on the extent to which these various foods are actually used as alternatives for butter, available data indicate that oleomargarine is the most widely used and probably the most acceptable by consumers as a replacement for butter. Consumption of oleomargarine for the United States is expected to be between 2 and 2½ pounds per capita more in 1944 than it was on the average in the years 1939–42. Consequently, it is of importance to consider the effects which increased use of oleomargarine as a food would have upon the welfare of consumers and butter producers, if consumers are given more opportunity to obtain it.

Since demands for butter (at expected prices during the war) are high relative to available supplies, the provision of additional oleomargarine is very unlikely to affect butter prices and returns to butter producers.[21]

Where butter and oleomargarine are both available to consumers, some individuals will consume only butter, others will consume both butter and oleomargarine, and others will use only oleomargarine. It was indicated previously that there would probably be no impairment of health if no other fats were made available to compensate for the reduction in average per capita butter supplies provided available quanti-

[21] Some factors in the effect on the postwar butter market of removal of the impediments to oleomargarine consumption are discussed in section IV.

ties of butter and other foods were equitably distributed among consumers. It is of interest, however, to consider the effect upon the health of those consumers in whose diets butter might be replaced by oleomargarine.

The minimum legal standard for the fat content of butter and oleomargarine is 80 per cent by weight. Recent assays indicate that the average vitamin A content of butter is about 13,500 units.[22] Fortified oleomargarine is legally required to contain a minimum of 9,000 International units of vitamin A per pound. Approximately 90 per cent of all oleomargarine sold domestically is fortified. Unfortified oleomargarines contain insignificant amounts of vitamin A.

The relative nutritive merits of butter and fortified oleomargarine as presented in the literature by scientists who have investigated this subject have been reviewed recently in a pamphlet published by the National Research Council. The excerpt below from this publication summarizes information on the subject:[23]

> "The present available scientific evidence indicates that when fortified margarine is used in place of butter as a source of fat in a mixed diet, no nutritional differences can be observed. Although important differences can be demonstrated between different fats in special experimental diets, these differences are unimportant when a customary mixed diet is used. The above statement can be made in respect to fortified margarine and it should be emphasized that all margarine should be fortified."

The findings of an earlier report prepared by the Council on Foods and Nutrition of the American Medical Association are in substantial agreement with this conclusion.[24]

Although fortified oleomargarine is nutritious and acceptable by many consumers as a spread, there are several kinds of trade barriers to its use. One-half of the states have

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[22] The state experiment stations in cooperation with the U. S. Department of Agriculture are developing improved procedures for analyzing the vitamin A content of butter. Results from these assays are as yet preliminary, but are indicative of the final results which may be expected.

[23] *A Report on Margarine*, Report of the Food and Nutrition Board, National Research Council, Reprint and Circular Series, No. 118, August, 1943, p. 18.

[24] Council on Foods and Nutrition, American Medical Association, "The Comparative Nutritional Value of Butter and Oleomargarine," *The Journal of the American Medical Association*, Aug. 22, 1942, vol. 119, pp. 1425–1427.

enacted excise taxes on oleomargarine, these taxes ranging from 5 to 15 cents per pound on the uncolored product.[25] Thirteen states have imposed license fees on retailers of oleomargarine; wholesalers of oleomargarine pay license fees in thirteen states. Twenty-nine states prohibit the sale of colored oleomargarine.[26] There is a federal tax of 10 cents per pound on colored oleomargarine. A federal tax of ¼ cent per pound is levied against uncolored oleomargarine, but this tax is so small as to have little effect upon consumption of the product. Some of these barriers—particularly the higher license fees—have the effect of keeping oleomargarine off the market in certain sections of the country. Some of these restrictions increase the prices which consumers have to pay for oleomargarine. If the excise taxes were removed during the war, OPA could immediately reduce the price ceilings on oleomargarine by at least the full amount of the tax. If no adjustments were made in the price ceilings, prices would probably be reduced very little from their present level, since the demand for the product at existing prices is relatively great. Removal of these taxes during peacetime would probably result in somewhat lower prices to consumers, higher profits to oleomargarine manufacturers, and perhaps higher returns to the producers of the raw materials than would occur if the taxes were maintained.

The federal laws were originally adopted to aid in identifying oleomargarine and preventing its fraudulent sale as butter. State oleomargarine legislation has been aimed not so much at preventing fraud and misrepresentation as providing protection for particular competing products.

The fact that butter has long been the most widely used

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[25] State taxes on oleomargarine do not in all cases apply equally to all kinds of the product. The excise taxes of fifteen states are levied only on certain types of oleomargarine, the taxes of nine states applying to all oleomargarines. For example, in some states a tax is levied on oleomargarines containing less than a specified minimum of fats of animal origin; in some states the taxes apply to oleomargarines containing imported vegetable oils.

[26] Refer to Taylor, Burtis, and Waugh, *Barriers to Internal Trade in Farm Products*, Bureau of Agricultural Econ., U. S. Department of Agriculture, Special Report, 1939, pp. 17–30, and to National Research Council, *op. cit.*, pp. 8–17.

fat spread in the United States and that it is yellow in color is a factor encouraging manufacturers of oleomargarine to try to color their product yellow. Consumers and producers have a "right" to demand that products be clearly identified and that there are adequate safeguards against misrepresentation. Similarity in the taste and appearance of butter and oleomargarine presents opportunity for misrepresentation. Taxes and other similar devices, however, are not the sole nor the best means for enforcing identification. The relatively heavier taxation and frequent outright prohibition of the sale of colored oleomargarine cannot be justified on grounds of preserving the identity of the product.[27] As is true with any food product, misrepresentation can be controlled by labelling requirements coupled with state and federal inspection of the conditions of manufacture and distribution, enforced through a technique such as licensing. This applies to distribution by licensed public eating places as well as by manufacturers, wholesalers and retailers, although enforcing identification in such establishments as restaurants is obviously more costly than inspection of the manufacture of the product.

B. *Rationing of Dairy Products*

In order to attain more equitable distribution of available supplies of butter and cheese, consumer rationing of these foods was inaugurated early in 1943. Evaporated milk was later added to the list of rationed dairy products. These dairy foods have been included in a group along with meats and edible fats and oils, which is being rationed by points. This procedure has been criticized on the basis that meats and such edible fats and oils as vegetable shortenings are not closely

[27] There has also been a special federal tax of $50 per year levied on each manufacturer of renovated or process butter, and a tax of ¼ cent is levied on each pound of this product. About 0.15 per cent of the total butter output in 1940 was process butter. The taxes affect its sale and consumption in a manner similar to the way in which oleomargarine taxes have affected the sale and consumption of oleomargarine. If renovated butter differs from other butter, the problem—like that of oleomargarine—is one of identifying the product so that it can be properly distinguished by consumers.

The issue of whether costs of inspection should be covered by license *fees* (if any) is not discussed. Total receipts from licenses might be higher than, lower than, or equal to the costs of inspection, depending upon the criteria established for distributing income.

related to butter and cheese, and that including all of these foods in the same group causes consumers considerable inconvenience in allocating their ration points.

It is true that including many different food items in a group of rationed foods does cause consumers some inconvenience in deciding how to allocate their ration points. But this is the same sort of inconvenience that is caused in the allocation of an individual's income among various items which he might purchase—the same sort of inconvenience arising from making any decision where, from a large number of alternatives, only a few may be selected. The more numerous and more varied the items in a group of rationed commodities, the greater is the opportunity for consumers to obtain maximum satisfaction in the allocation of their ration points. When the satisfaction of consumers is to be considered in evaluating various rationing procedures, placing dairy products in a group of foods including meat is to be commended.

The War Food Administration placed limitations on sales of fluid milk and cream in many of the larger cities late in 1943. In most of these cities, any distributor's monthly sales of fluid milk are limited to not more than the aggregate amount sold during June, 1943, and his total monthly sales of cream cannot exceed 75 per cent of his sales during June. These limitations may be altered by the War Food Administration as supplies change. There are also similar restrictions on the distribution of cottage cheese and some other by-products of fluid milk and cream. Individual consumers are not limited in their purchases, except insofar as restrictions are invoked by distributors. Consumer rationing of fluid milk consequently rests with milk distributors.

The primary purpose of limitations on sales of fluid milk is to make available more milk for use in manufactured dairy products. It is estimated that restrictions on sales of fluid milk will make available during 1944 about 10 per cent less fluid milk, 9 per cent more creamery butter, 14 per cent more cheese, 20 per cent more evaporated milk, 7 per cent more dried whole milk, and 34 per cent more dried skim

milk than would be available in the absence of such restrictions.[28]

Wide variations in individuals' requirements for milk make equitable fluid milk rationing difficult. Children require more milk than do adults, and there may be considerable variation in adult requirements. Nursing mothers, for example, require more milk than the average adult. Many consumers had insufficient quantities of milk in June, 1943. Although urban fluid milk and cream consumption in 1943 exceeded that of 1942 by about 11 per cent, it does not seem likely that the increase was proportionately greatest among consumers whose intake of milk was already nutritionally sufficient. Limitations on milk sales resulting from physical shortages would probably be necessary in some areas even though there was no intent to make more milk available for other products. Where physical shortages do not exist, however, limitations on sales of fluid milk seem inadvisable from a nutritive standpoint, unless the additional milk that is made available for other dairy products goes into foods whose distribution among the population adds more to health than would the fluid milk. For example, unless all of the skim milk can be dried or other-

[28] Expected production of some dairy products in 1944 with and without restrictions on sales of fluid milk is indicated in the following table taken from *The Dairy Situation*, Bureau of Agricultural Economics, U. S. Department of Agriculture, September, 1943, p. 10:

Product	With Fluid Milk Sales Restricted (Millions of Pounds)	Without Fluid Milk Sales Restricted (Millions of Pounds)
Fluid milk and cream in urban areas	40,565	45,500
Creamery butter	1,715	1,575
American cheese	700	615
Evaporated milk	2,865	2,400
Dried whole milk	150	140
Dried skim milk	470	350

These estimates indicate that of the milk solids diverted from fluid milk into other products, slightly less than three-fifths is expected to be redirected into human consumption. This results from the fact that only about one-third of the non-fat milk solids from the milk directed into butter will be recovered for human consumption in the form of dried skim milk.

wise directly made available for human consumption, a reduction in fluid milk consumption in order to make available more butter is not warranted from a nutritional standpoint.

The success of any rationing procedure depends partly upon the way in which rationing distributes the goods among the population and the simplicity of the administrative procedure. The level of milk consumption is relatively high in the areas where limitations have been placed upon dealers' sales of milk. No serious reductions have to be distributed among the population. The administration of such limitations is relatively simple as compared to point rationing.

If nationwide rationing of fluid milk or drastic cuts in the consumption of fluid milk in many areas is considered desirable, however, point rationing rather than rationing by dealers seems advisable. Giving sellers the responsibility for determining individual rations has not proven very successful where this type of rationing has been applied to other commodities, particularly when the level of available supplies has been markedly reduced. Fluid milk, cream, and evaporated milk could be included in a group of foods which could be rather easily rationed under the point system. Special procedures could be established to minimize the collection and accounting of points.

IV. SOME POSTWAR IMPLICATIONS OF WARTIME DEVELOPMENTS IN THE DAIRY INDUSTRY

Developments which are made during the war both within the dairy industry and independently of it are likely to be of importance in the postwar dairy picture. This section is not an analysis of these developments. It is merely an attempt to list some of the more important ones and to point out some of their possible implications.

The Postwar Market for Dried Skim Milk. As has been pointed out previously in this analysis, the demand for dried skim milk has increased sharply during the war. Because of its high food value per pound and its storability, a large proportion of the dried non-fat milk solids produced thus far during the war has gone to our armed forces and to lend-lease. If supplies had been sufficient, however, it is likely that domestic consumption would have increased markedly, particularly if milk solids were used in bread.

Forecasts of actual quantities of dried skim milk which will be consumed and the prices which will prevail in the years after the war can be little more than guesses. Approximately 270 million pounds of dried skim milk were manufactured for human food in 1939. Most of this was used domestically, largely by confectioners, bakers, ice cream manufacturers, and in the preparation of various commercial products. Although wartime demands (including domestic requirements for the fortification of bread) have been nearly four times as large as this prewar figure, there is little likelihood that demands in the period following reconstruction will approximate wartime requirements. Many countries other than the United States can supply large volumes of dried skim milk. Although dried skim milk is a relatively inexpensive source of animal proteins and other important nutrients, many of these nutrients may be provided at even lower costs

from such foods as soybeans, on a long run basis. Soybean flour may be widely used as a means of improving the nutritive quality of such foods as bread. These factors should be kept in mind in estimating the postwar dried skim milk market.

Removal of taxes and license fees on the manufacture and sale of oleomargarine. One cannot estimate with any accuracy the probability that restrictions on the manufacture and sale of oleomargarine will be relaxed. Some of the general implications to the dairy industry of such a development, however, may be of interest.

To the extent that butter and oleomargarine may replace each other and that prices for oleomargarine are lower with the removal of restrictions than they would be if taxes, license fees, and other impediments were maintained, removal of the restrictions might mean a somewhat lower short-run level of returns to butterfat than would otherwise prevail. How much lower butter prices would be is difficult to estimate. Consumers generally prefer butter to oleomargarine and butter would probably continue to command a substantial premium.

The restrictions to the sale and manufacture of oleomargarine are important to dairymen, since such restrictions influence their incomes. And viewed in isolation, the restrictions on oleomargarine are of relatively little significance to the general public. However, the ramifications of using such a procedure to influence incomes are of much greater significance than the immediate effects upon the price of butter and other dairy products. Such restrictions interfere with organizing our economy in a manner which will enable maximum production from our limited resources. Extension of this principle to other fields would tie the economy in knots and make its proper functioning impossible. The long-run effect of attempting through artificial price maintenance to influence the distribution of incomes may be a drastically smaller total income to distribute. Each group trying to get a larger share of the national income through such restrictions may find that although its share is larger, its absolute quantity

may be smaller than would be obtained in an economy in which such restrictions were absent. Furthermore, even in the short-run, retaliatory action against not only butter but other dairy products is encouraged by the restrictions imposed on oleomargarine.

Wartime changes in technology. Some improvements in technology may improve markets for dairy products. On the other hand, some technological improvements may encourage the use of other items to replace dairy products. For example, improvements in the drying of whole milk and skim milk help to make these products more acceptable. Increased use of vegetable proteins in industrial processes, however, may reduce the market for such products as casein.

Improvements in technology will prove of most significance to the dairy industry if the application of technology is given greater opportunity than it has been granted in the past. Some legally established specifications for the compositions of dairy products impede the application of improved techniques to making these products more acceptable. A re-examination of these specifications toward making them more flexible may be desirable both from the standpoint of consumers and producers of dairy products.

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APPENDIX

Data relating to the efficiencies with which various kinds of livestock convert feed into food are not readily available. This is the situation particularly when one considers average rates of conversion of the different kinds of livestock as well as the variation in rates arising out of differences in productivity and differences in the way in which the livestock product is ultimately consumed as food. Appendix tables 1–8 represent an attempt to provide a rough basis for such comparisons.

These comparisons should not be accepted as the final word on the subject. Several limitations must be imposed in interpreting them. First of all, when one compares the amounts of food nutrients produced by various kinds of livestock from a given quantity of feed, it must be assumed that at least part of the feed can be used by any of the kinds of livestock included in the comparison. Hogs and poultry can utilize only limited quantities of roughages. However, since the total digestible nutrients provided by roughages can be substituted in the rations of dairy cattle, beef, or sheep for total digestible nutrients furnished from concentrate feeds, such comparisons are valid for relatively small changes in the output of the various kinds of livestock.

A second limitation arises from the fact that livestock products are a composite of a number of nutrients. In comparing only relative returns of one nutrient, the other nutrients produced jointly are implicitly valued at zero.

The rates of conversion are based on average nutritive compositions of various livestock products and upon estimated rates of conversion of feed into these products. It should be remembered that there is some variability in the compositions of the products and considerable variability in the rates of conversion. Furthermore, since the population of feeding rates

is not known, the values used are estimates and are subject to errors.

In spite of these limitations, the assembling of these data in their present form would appear to be more satisfactory than other available data for indicating relative resource costs of providing given amounts of protein and carbohydrate equivalent for human consumption from various kinds of livestock, considering varying levels of productivity as well as variations in the way in which the product is used.

In converting various feeds to the common denominator of total digestible nutrients, it was assumed that each pound of corn contains approximately 0.8 pound of total digestible nutrients, a pound of oats contains 0.7 pound of digestible nutrients, each pound of other feed concentrates contain about 0.75 pound of total digestible nutrients, a pound of silage contains approximately 0.15 pound of total digestible nutrients, and a pound of hay contains about 0.5 pound of total digestible nutrients. There is, of course, variability in the percentages of total digestible nutrients contained in different samples of the same general kind of feeds.

Feed supplied from pasture has been omitted in these comparisons, primarily because of the difficulties involved in comparing different kinds of pasture. This omission increases somewhat the estimated relative efficiencies of roughage consuming animals as compared to other animals.

Kind of Animal	Level of Productivity	Use of Product	Average Lbs. of Protein in the Food Product From 100 Lbs. of Total Digestible Nutrients Consumed
Dairy cow	8,000 lbs. milk per year	whole milk products[b]	6.0
Dairy cow	6,000 lbs. milk per year	whole milk products	5.3
Chickens	live weight 2 lbs.	meat	4.1
Dairy cow	4,000 lbs. milk per year	whole milk products	3.9
Chickens	live weight 3 lbs.	meat	3.8
Chickens	13½ doz. eggs per hen per yr.	eggs	3.8
Chickens	live weight 4 lbs.	meat	3.4
Chickens	10 doz. eggs per hen per yr.	eggs	3.3
Chickens	live weight 5 lbs.	meat	3.1
Chickens	live weight 6 lbs.	meat	2.8
Chickens	8 doz. eggs per hen per yr.	eggs	2.7
Hogs	live weight 160 lbs.	meat	2.4
Hogs	live weight 190 lbs.	meat	2.2
Hogs	live weight 210 lbs.	meat	2.1
Hogs	live weight 230 lbs.	meat	2.0
Hogs	live weight 250 lbs.	meat	1.9
Hogs	live weight 310 lbs.	meat	1.6
Beef calves	weight incr. from 400 to 800 lbs.	meat	1.5
Dairy cow	8,000 lbs. milk per year	butter, skim fed to hogs	1.2
Dairy cow	6,000 lbs. milk per year	butter, skim fed to hogs	1.1
Beef yearlings	wt. incr. from 650 to 1,000 lbs.	meat	1.1
Dairy cow	4,000 lbs. milk per year	butter, skim fed to hogs	1.0
Beef, 2 yr. old	wt. incr. from 850 to 1,100 lbs.	meat	0.9
Lambs	wt. incr. from 60 to 90 lbs.	meat	0.8

[a] Based on returns of animal products as summarized in farm records and feeding experiments. (See Appendix tables 3–8.)

The comparisons in this table consider only relative protein returns, thus evaluating the other nutrients produced jointly with the protein at zero.

For milk, butter, and eggs, these returns include all meat produced as a joint product. Feed consumption includes maintenance and replacement.

[b] Protein returns from cows producing milk for use in cheese will be about five-sixths of the returns from equivalent cows producing milk for use in whole milk products.

TABLE 2

RELATIVE EFFICIENCIES OF VARIOUS KINDS OF LIVESTOCK IN CONVERTING FEED INTO FOOD ENERGY[a]

Kind of Animal	Level of Productivity or Weight Marketed	Use of Product	Av. Lbs. of Carbohydrate Equivalent in the Food Produced From 100 Lbs. of Total Digestible Nutrients Consumed[b]
Hogs	live weight 310 lbs.	meat	29.6
Hogs	live weight 250 lbs.	meat	29.5
Hogs	live weight 230 lbs.	meat	29.0
Dairy cow	8,000 lbs. milk per year	whole milk products[c]	28.6
Hogs	live weight 210 lbs.	meat	28.2
Hogs	live weight 190 lbs.	meat	27.0
Dairy cow	8,000 lbs. milk per year	butter, skim fed to hogs	25.2
Dairy cow	6,000 lbs. milk per year	whole milk products	24.8
Hogs	live weight 160 lbs.	meat	24.6
Dairy cow	6,000 lbs. milk per year	butter, skim fed to hogs	22.1
Dairy cow	4,000 lbs. milk per year	whole milk products	18.2
Dairy cow	4,000 lbs. milk per year	butter, skim fed to hogs	16.0
Chickens	13½ doz. eggs per hen per yr.	eggs	11.3
Beef yearling	wt. incr. from 650 to 1,000 lbs.	meat	11.0
Beef, 2-yr. old	wt. incr. from 850 to 1,100 lbs.	meat	11.0
Beef calves	wt. incr. from 400 to 800 lbs.	meat	10.6
Chickens	10 doz. eggs per hen per yr..	eggs	9.8
Chickens	live weight 3 lbs.	meat	8.5
Chickens	8 doz. eggs per hen per yr..	eggs	8.0
Lambs	wt. incr. from 60 to 90 lbs..	meat	8.0
Chickens	live weight 4 lbs.	meat	7.8
Chickens	live weight 2 lbs.	meat	7.4
Chickens	live weight 5 lbs.	meat	7.4
Chickens	live weight 6 lbs.	meat	6.7

[a] Same bases for calculation as table 1 (See Appendix tables 3–8).

The comparisons in this table consider only relative returns of food energy, thus evaluating the other nutrients produced jointly with food energy at zero.

For milk, butter, and eggs these returns include all meat produced as a joint product. Food consumption includes maintenance and replacement.

[b] When foods or feeds are ingested they yield energy in addition to furnishing essential nutrients. The number of units of energy produced depends largely upon the relative amounts of the feed nutrients (protein, carbohydrate, and fat) in each feedstuff. Equal units of weight of protein and carbohydrate produce essentially equal amounts of energy, those of fat 2.25 times as much.

[c] Energy returns from cows producing milk for use in cheese will be about four-fifths of the returns from equivalent cows producing milk used in whole milk products.

TABLE 3

DATA RELATING TO EFFICIENCY OF HOGS AS CONVERTERS OF FEED INTO EDIBLE PROTEIN AND CARBOHYDRATE EQUIVALENT

Live Wt. (Lbs.)	Composition of Animal (Lbs. in Food per 100 Lbs. Live Wt.)[a]			Total Feed Requirements		Nutrients Produced[c] (Edible Product)		Average Lbs. Protein Produced per 100 Lbs. T.D.N.	Average Lbs. CHO Equivalent Produced per 100 Lbs. T.D.N.	Additional Lbs. Prot. Produced per 100 Lbs. Additional T.D.N.	Additional Lbs. CHO Equivalent Produced per 100 Lbs. Additional T.D.N.
	Protein	Fat	CHO[b] Equivalent	Lbs. Feed for Pig[c]	Total T.D.N. (Includes Sow Req.)[d]	Protein (Lbs.)	CHO Equivalent (Lbs.)				
40	8.70	9.0	29.0	37.5	190	5.0	30.5	2.6	16.1		
80	8.20	16.0	44.2	177.8	302	8.1	54.3	2.7	18.0	2.8	21.2
120	7.80	23.0	59.6	332.8	426	10.9	90.4	2.8	21.2	2.3	29.1
160	7.30	29.6	73.9	498.1	558	13.2	137.1	2.4	24.6	1.8	35.4
190	7.00	34.5	84.6	632.6	666	14.8	179.6	2.2	27.0	1.5	39.4
210	6.80	37.0	90.1	723.9	739	15.8	208.1	2.1	28.2	1.3	39.0
230	6.55	39.0	94.3	817.4	814	16.6	235.8	2.0	29.0	1.0	36.9
250	6.30	40.5	97.4	913.1	890	17.3	262.4	1.9	29.5	0.9	35.0
270	6.05	41.7	99.9	1,012.1	970	17.9	288.6	1.8	29.8	0.7	32.8
290	5.80	42.7	101.9	1,114.1	1,051	18.4	314.4	1.7	29.9	0.6	31.8
310	5.55	43.0	102.3	1,218.8	1,135	18.7	336.0	1.6	29.6	0.4	25.7

[a] Based on data presented in *Proximate Composition of American Food Materials*, U.S.D.A. Circular No. 549; *Food and Life*, Yearbook of Agriculture, 1939, p. 458; and unpublished data from Bureau of Agricultural Economics, U. S. Department of Agriculture. Offal yields were assumed to add 0.55 lbs. of protein per 100 pounds live weight (at all weights). Yields have been directly calculated for weights of 190 lbs., 230 lbs., and 270 lbs., and have been interpolated for the other weights.

[b] 1 lb. protein = 1 lb. CHO equivalent; 1 lb. fat = 2.25 lbs. CHO equivalent.

[c] Based on data from Robert Menze, *Applications of the Law of Diminishing Returns to the Production of Hogs*, unpublished Master's Thesis, Iowa State College, 1941, page 81.

[d] Requirements for the sow are estimated from John H. Sitterley, *Feed Consumed by Livestock*, Ohio State University, Extension Bul. No. 203, page 46. These requirements for one year were as follows:

	Lbs.	T.D.N.
Corn	1,466	1,173
Oats	203	142
Other concentrates	57	45
Supplement	114	86
Total		1,446

It was assumed that the sow was fed for 8 months and that there were 6 pigs in the litter. Hence, sow requirements = 1,446 × 2/3 × 1/6 = 160 lbs. T.D.N. per pig

[e] It was assumed that the sow gained 135 lbs. or 22 lbs. per pig. Composition of this gain was assumed to be 7 per cent protein and 35 per cent fat. If the composition of the sow gain was assumed to be 5 per cent protein and 45 per cent fat, the average return for a 230 lb. hog would be 2.0 lbs. protein and 29.5 lbs. carbohydrate equivalent per 100 lbs. of T.D.N.

TABLE 4

DATA RELATING TO EFFICIENCY OF BEEF CATTLE AS CONVERTERS OF FEED INTO EDIBLE PROTEIN AND CARBOHYDRATE EQUIVALENT

Live Weight (Lbs.)	Composition of Animal (Lbs. in Food per 100 Lbs. Live Wt.)[a]			Nutrients Produced by Animal (Lbs.)		Total Digestible Nutrients Required[c]	Lbs. Pork Produced[d]	Total Nutrients Produced (Edible Product)		Average Lbs. Nutrients Produced per 100 Lbs. Total Digestible Nutrients in the Feed	
	Protein	Fat	CHO Equivalent[b]	Protein (Lbs.)	CHO Equiv. (Lbs.)[b]			Protein	CHO Equiv. (Lbs.)[b]	Protein	CHO Equiv.[b]
Calves											
400	9.0	6.0	22.5	.....	.....	.....	.....	.....	.....	.....	.....
800	8.6	13.0	37.8	32.8	212	2520	60	36.7	268	1.5	10.6
Yearlings											
650	8.8	7.3	25.2	.....	.....	.....	.....	.....	.....	.....	.....
1000	8.3	14.0	39.8	25.8	234	2730	70	30.4	300	1.1	11.0
2-yr. olds											
850	8.6	8.5	27.7	.....	.....	.....	.....	.....	.....	.....	.....
1100	8.1	15.0	41.9	16.0	226	2250	62	20.0	247	0.9	11.0

[a] Based on data presented in Chatfield and Adams, *Proximate Composition of American Food Materials*, U.S.D.A., Cir. No. 549. It was assumed that feeder calves would have the same composition as common cattle, yearling feeders the same composition as high common, and 2-year-olds the composition of low medium slaughter cattle. The slaughter grade was considered to be good with an adjustment for weight. If cattle were fed to choice grade by feeding longer, protein returns would have been reduced appreciably, while energy returns would increase. If cattle were fed to lighter weights and to medium grade, protein returns would be higher and energy returns lower. It should be noted that the composition of the animal is subject to considerable variation.

[b] Protein is given a weight of one; fat a weight of 2.25.

[c] There is considerable variation in the feed requirements, exclusive of pasture, for gains on the different weights of feeder cattle. The figures used here are largely based on publications by the U.S.D.A. and state colleges. A study of more than 100,000 cattle for the years 1919–23 indicated the following relationships in feed requirement per cwt. of gain for the three classifications of feeder cattle used in the table.

	Feed Units of Concentrates	Feed Units of Dry Roughage	Feed Units of Silage	Total Feed Units	T.D.N.
Calves	682	110	65	857	725
Yearlings	691	138	173	1,002	880
2-year-olds	841	151	168	1,160	1,015

(Source: R. H. Wilcox, *et al.*, *Costs and Methods of Fattening Beef Cattle in the Corn Belt, 1919–23*, U.S.D.A., Tech. Bul. No. 23, page 45.)

R. D. Jennings estimates that in addition to the usual supplies of roughages it requires the following quantities of concentrates for 100 lbs. of gain: calves, 575; yearlings, 685; and 2-year-olds, 750 lbs. If the roughages, except pasture, are added to these figures, the following approximate amounts of total digestible nutrients are required: calves, 670; yearlings, 790; 2-year-olds, 880. (R. D. Jennings, *Feed Consumption by Livestock 1910–41*, U.S.D.A., Cir. No. 670, pp. 56–57.)

A summary of 75 feeding trials at Corn Belt experiment stations indicates the following requirements (total digestible nutrients) for 100 lbs. of gain: calves, 540; yearlings, 650; and 2-year-olds, 780. (John H. Sitterly, *Feed Consumed by Livestock*, Ohio State College, Extension Bul. 203, p. 13.) A comparable series of studies reported by Morrison indicates the following requirements—510, 665, and 735. It is to be anticipated that feed requirements would be lower under experimental than farm conditions. Two reasons are apparent. First, the experiment stations usually have better quality calves and probably use superior rations. Second, and perhaps more important, farm records are usually based on purchase weights and sale weights, while the experimental results are usually on the basis of weights at the feed lot. This factor alone increases feed costs under farm conditions by 10 to 20 per cent as the feeder cattle will shrink from 3 to 7 per cent and the finished cattle from 2 to 6 per cent.

The feed requirements in total digestible nutrients used in this table per 100 lbs. gain are: calves, 630; yearlings, 780; 2-year-olds, 900. These are approximately 15 per cent higher than the experimental results and about 15 to 20 per cent less than extensive study of farm feeding requirements referred to above. The requirements are similar to those calculated from the data presented by Jennings.

[d] Based on the assumption that on the average 21 lbs. of gain are produced by hogs following grain-fed cattle per 100 lbs. of gain by the cattle. Calves produce less (15 lbs.), yearlings about the average (20 lbs.), and 2-year-olds more than the average (25 lbs.) Hog composition was on the basis of 230 lbs. at time of marketing.

TABLE 5

DATA PERTAINING TO EFFICIENCY OF CHICKENS (FOR MEAT) AS CONVERTERS OF FEED INTO EDIBLE PROTEIN AND CARBOHYDRATE EQUIVALENT

Live Weight (Lbs.)	Composition of Animal (Lbs. in Food per 100 Lbs. Live Wt.)[a]			Total Lbs. T.D.N. Required[c]	Average Lbs. Protein Returned per 100 Lbs. T.D.N.	Average Lbs. CHO Equivalent[b] per 100 Lbs. T.D.N.	Additional Lbs. Protein Returned per 100 Lbs. Additional T.D.N.	Additional Lbs. CHO Equivalent[b] Returned per 100 Lbs. Additional T.D.N.
	Protein	Fat	CHO Equivalent[b]					
2	9.8	3.5	17.7	4.8	4.1	7.4	.....	.....
3	10.6	5.8	23.7	8.4	3.8	8.5	3.6	10.5
4	10.8	6.3	25.0	12.8	3.4	7.8	2.8	6.4
5	11.1	6.9	25.7	18.0	3.1	7.4	2.4	4.6
6	11.1	6.9	26.7	24.0	2.8	6.7	1.8	3.1

[a] Based on data presented in *Proximate Composition of American Food Materials*, U.S.D.A., Cir. No. 549.

[b] 1 lb. protein = 1 lb. CHO equivalent; 1 lb. fat = 2.25 lbs. CHO equivalent.

[c] Feed requirements are based on data presented in *The U. S. Egg and Poultry Magazine* by Annin and Halpin, University of Wisconsin, Nov., 1938, page 692, and Wisconsin Agricultural Experiment Station, Bulletin No. 434, page 24. Losses due to death are given consideration in the feed requirements.

TABLE 6

DATA PERTAINING TO EFFICIENCY OF CHICKENS (PRODUCING EGGS) AS CONVERTERS OF FEED INTO EDIBLE PROTEIN AND CARBOHYDRATE EQUIVALENT

Level of Annual Production (Dozen)	Composition of Product[a] (Lbs. in Food per 100 Lbs. Marketable Product)			Lbs. T.D.N. Required[c]	Average Lbs. Protein Returned From Eggs per 100 Lbs. T.D.N.	Average Lbs. CHO Equivalent[b] Returned From Eggs per 100 Lbs. T.D.N.	Av. Lbs. Protein Returned From Eggs and Meat per 100 Lbs. T.D.N.[d]	Av. Lbs. CHO Equiv.[b] Returned From Eggs and Meat per 100 Lbs. T.D.N.[d]
	Protein	Fat	CHO Equivalent[b]					
13½	11.4	10.2	35.0	68.4	3.4	10.4	3.8	11.3
10	11.4	10.2	35.0	59.6	2.9	8.8	3.3	9.8
8	11.4	10.2	35.0	59.6	2.3	7.0	2.7	8.0

13½	11.4	10.2	35.0	68.4	3.4	10.4	3.8	11.5
10	11.4	10.2	35.0	59.6	2.9	8.8	3.3	9.8
8	11.4	10.2	35.0	59.6	2.3	7.0	2.7	8.0

[a] From *Proximate Composition of American Food Materials*, U.S.D.A., Circular No. 549.

[b] 1 lb. protein = 1 lb. CHO equivalent; 1 lb. fat = 2.25 lbs. CHO equivalent.

[c] Based on data presented by John H. Sitterley, *Feed Consumed by Livestock*, Ohio State University, Extension Bul. No. 203. The requirements were as follows:

162 eggs per hen (flock of 100 hens):

	Lbs.	T.D.N.
Corn	2,448	1,958
Wheat	1,273	1,018
Oats	712	498
Mash	4,211	3,369
		6,843

120 eggs per hen (flock of 100 hens):

	Lbs.	T.D.N.
Corn	2,055	1,644
Wheat	1,042	834
Oats	387	271
Mash	4,016	3,213
		5,962

These figures include maintenance of the flock at 100 hens. It was assumed that hens producing 8 doz. eggs per year consumed the same amount of feed as did hens producing 120 eggs per year.

[d] Supplementary meat yields are computed as follows:

(a) Mortality rate of flock = 21 per cent per year.
(b) Average weight of birds = 5 lbs.
(c) Of 100 hens in flock at beginning of year, 66 are replaced by the end of the year.
(d) Hence, 45 birds are edible.
(e) Meat yield = 45 × 5 = 225 lbs. meat or 25.0 lbs. protein and 60.0 lbs. CHO equivalent from 100-hen flock.
(f) Hence, supplementary meat yield is 0.4 lbs. protein and 0.9 lbs. fat per 100 lbs. T.D.N. in high producing flocks, and 0.42 lbs. protein and 1.0 lbs. fat per 100 lbs. T.D.N. in low and medium flocks.

TABLE 7

DATA RELATING TO EFFICIENCY OF DAIRY COWS AS CONVERTERS OF FEED INTO EDIBLE PROTEIN AND CARBOHYDRATE EQUIVALENT

Annual Production (Lbs.) Milk	Composition of Food (Lbs. Nutrient per 100 Lbs. Milk)[a]			T.D.N. Consumed			Nutrients Produced (in Milk)		Nutrients Produced Including Supplementary (Edible Product)		Av. Protein Produced per 100 Lbs. T.D.N.	Av. CHO Equivalent[b] Produced per 100 Lbs. T.D.N.
	Protein	Fat	CHO[b]	Current Production Including Cow Maintenance[c]	Replacement of Herd[d]	Total	Protein (Lbs.)	CHO Equivalent[b] (Lbs.)	Meat and Milk Proteins (Lbs.)[e]	Meat and Milk CHO Equivalent[b] (Lbs.)		
Milk used in whole milk products:												
4,000...	3.5	3.9	17.2	3,480	597	4,077	140	688	161	741	3.9	18.2
6,000...	3.5	3.9	17.2	3,780	597	4,377	210	1,032	231	1,085	5.3	24.8
8,000...	3.5	3.9	17.2	4,400	597	4,997	280	1,376	301	1,429	6.0	28.6
Milk used in Butter, skim milk fed to hogs:												
4,000...	156 lb. b.f.	3.9	8.8	3,480	597	4,077	.....	351	40[f]	653	1.0	16.0
6,000...	234 lb. b.f.	3.9	8.8	3,780	597	4,377	.....	526	50	964	1.1	22.1
8,000...	312 lb. b.f.	3.9	8.8	4,400	597	4,997	.....	702	59	1,261	1.2	25.2

[a] Based on data presented in *Proximate Composition of American Food Materials*, U.S.D.A., Cir. No. 549.

[b] 1 lb. protein = 1 lb. CHO equivalent; 1 lb. fat = 2.25 lbs. CHO equivalent.

[c] These feed requiments were estimated from linear regression fitted to the following data obtained from John H. Sitterley, *Feed Consumed by Livestock*, Ohio State University Extension Bul. No. 203, page 31. The requirements given for one year at different levels of milk production (in total pounds per cow) are as follows:

Annual Milk Production per Cow

Kind of Feed	4,048 Lbs.		5,600 Lbs.		6,664 Lbs.		7,761 Lbs.		8,626 Lbs.		10,101 Lbs.	
	Feed	T.D.N.	Feed	T.D.N.	Feed	T.D.N.	Feed	T.D.N.	Feed	T.D.N.	Feed	T.D.N.
Silage	5,100	765	5,400	810	5,300	795	5,400	810	5,500	825	5,500	825
Hay	2,500	1,250	2,280	1,140	2,300	1,150	2,560	1,280	2,410	1,205	2,460	1,230
Stover	360	180	350	175	420	210	390	195	350	175	270	135
Concentrates	1,660	1,328	2,040	1,632	2,180	1,744	2,660	2,128	2,920	2,336	3,370	2,696
Total		3,523		3,757		3,899		4,413		4,541		4,886

[d] A replacement rate of 21.6 per cent is used. This is derived by taking the total number of dairy heifers 1 to 2 years old as a percentage of the total number of milk cows over 2 years old. Total digestible nutrient requirements for the heifer up to 24 months are estimated from John H. Sitterley, *Feed Consumed by Livestock*, Ohio State University, Extension Bul. No. 203, page 38, as being 2,765. These requirements are slightly lower than those given in Henry B. Morrison, *Feeds and Feeding*, 20th Edition, page 616.

[e] It was assumed that the dairy cow herd produces 100 lbs. of dressed beef carcass (common grade) and 32 lbs. of dressed veal carcass annually per milk cow. This is equivalent to 21 lbs. protein and 53 lbs. CHO equivalent.

[f] In addition to the beef and veal produced by the dairy cow, a further correction is made for the value of skim milk used in hog feeding. 100 lbs. skim milk or buttermilk is equivalent to 30 lbs. corn or 24 lbs. T.D.N., although in cases of protein-deficient rations, the value is higher. It is assumed that the hogs will be sold at 210 lbs. The protein and CHO equivalent added was derived as follows:

Level of Milk Production Lbs.	Skim Milk and Buttermilk Produced Lbs.	T.D.N. Lbs.	Protein Lbs.	CHO Equivalent Lbs.
4,000	3,800	892	19	249
6,000	5,700	1,368	29	385
8,000	7,600	1,824	38	506

TABLE 8

DATA RELATING TO EFFICIENCY OF LAMBS AS CONVERTERS OF FEED INTO EDIBLE PROTEIN AND CARBOHYDRATE EQUIVALENT[a]

Live Weight (Lbs.)	Composition of Animal (Lbs. Edible Nutrient per 100 Lbs. Live Wt.)[b]		Nutrients Produced (Edible Product)		T.D.N. Required for Gain[c]	Lbs. Protein per 100 Lbs. T.D.N.	Lbs. CHO Equivalent[d] per 100 Lbs. T.D.N.
	Protein	Fat	Protein (Lbs.)	CHO Equivalent (Lbs.)[d]			
60	6.1	8.2					
90	5.2	17.7	1.0	11.0	135	0.8	8.0

[a] It is assumed that lambs are put on feed at 60 lbs. and sold at 90 lbs.

[b] Based on data presented in *Proximate Composition of American Food Materials*, U.S.D.A., Cir. No. 549.

[c] Requirements estimated from data presented by R. D. Jennings, *op. cit.*, p. 56. Requirements given per 100 lbs. gain are as follows:

	Feed Units	Lbs. T.D.N.
Concentrates	336	288
Roughage	160	128
Total		416

[d] 1 lb. protein = 1 lb. CHO equivalent; 1 lb. fat = 2.25 lb. CHO equivalent.

TABLE 9

PER ACRE FAT YIELDS FROM DAIRY COWS, SOYBEANS, AND HOGS IN FOUR CORN BELT STATES[a]

Source of Fat[b]	Returns per Acre of Land	
	Direct Fat Returns From Crop or Livestock[c] (Lbs.)	Total Fat Returns (Including Yield From By-product Feeds)[d] (Lbs.)
Dairy cows (butterfat)	87[e]	130[h]
Soybeans	180[f]	317[i]
Hogs	218[g]	222[j]

[a] Throughout this analysis the terms "fats" and "oils" have been utilized as if they were interchangeable. "Fats" differ from "oils" merely in their solidarity or liquidity at various temperatures—or in the degree to which they are saturated with hydrogen. The various fats differ further, however, in the degree to which they contain certain elements soluble in fat.

The comparisons in this table consider only relative returns of fat and ignore the other nutrients produced jointly with the fat. Thus these comparisons are strictly valid only on the assumption that the commodity is produced solely for the fat.

[b] Flaxseed is also grown fairly extensively in the north central states, although a relatively small proportion of the total output of linseed oil is converted into food products for domestic consumption. On the basis of average yields for the United States for the period 1937–41, an acre of flaxseed yielded an average of 178 lbs. of fat, excluding the indirect fat returns from feeding the oil meal to hogs. If these indirect returns are also considered, the total fat yield averaged 248 lbs. per acre.

[c] Based on average yields in Iowa, Illinois, Indiana, and Ohio for the 5 years, 1937–41.

[d] Total fat returns include the fat obtained directly from the crop or livestock and the fat returned if the by-product feeds are fed to hogs.

[e] Assumes a cow producing 6,000 lbs. of 3.9 per cent milk or 234 lbs. of butterfat annually. Ration assumed was based on data in table 7, and included 5,400 lbs. silage, 2,200 lbs. hay, 2,100 lbs. concentrates, plus 16 per cent additional for herd maintenance. The production of these feeds (which excluded pasture) required 2.7 acres of land.

[f] Average yield of 20 bu. per acre. Soybeans average 15 per cent extractable fat.

[g] Assumes hog is marketed at 230 lbs. live weight. Feed requirements include maintenance of the sow. Fat returns also include those of the sow. Total feed consumption was based on data presented in table 3 and was assumed to be 950 lbs. of corn and 70 lbs. of soybean oil meal. This feed would require 0.44 acres of land, exclusive of pasture.

[h] It was assumed that the skim milk by-product of the butterfat would produce 38 lbs. of fat if fed to hogs. An additional 5 lbs. of fat is produced from the average of 100 lbs. of common beef carcass and 32 lbs. of veal produced annually.

[i] 20 bushels of soybeans yields 960 lbs. of soybean oil meal. When fed to hogs this would return 137 lbs. of fat, assuming a pound of soybean oil meal is equivalent to 1.75 lbs. of corn. (See R. D. Jennings, *Feed Consumption by Livestock, 1910-14*, U.S.D.A., Circular No. 670, table 8).

[j] Assumes 3 lbs. of tankage is yielded from a 230-lb. hog. When fed to hogs a pound of tankage was assumed equivalent to 2 lbs. of corn. (See Jennings, *ibid.*)

TABLE 10

AVERAGE YIELD OF FOOD ENERGY AND PROTEINS PER 100 HOURS OF LABOR FROM SPECIFIED LIVESTOCK AND LIVESTOCK PRODUCTS[a]

Livestock or Livestock Products	Energy Value (1,000 Calories)	Protein (Lbs.)
Whole milk	791	89
Butter[b]	425	1
Pork and lard	1618	58
All beef cattle	310	45
Fattening steers	289	42
Fattening lambs	521	58
Chicken enterprise	317	61

[a] These data are from Raymond P. Christensen, *Using Resources to Meet Food Needs*, Bureau of Agricultural Economics, U.S.D.A., May, 1943, mimeographed, page 30, table 12. They do not include in either set of comparisons the products produced jointly with the food energy and the protein. Furthermore, by-product yields are not considered.

[b] The returns from feeding the skim milk to livestock are not included in these comparisons. If this is considered, the protein returns from butter production are approximately one-fifth of those from whole milk, assuming the cow produces 6,000 lbs. of milk annually. The energy returns will be about ¾ those of whole milk. If the skim milk is used for human consumption, the returns from butter plus skim milk are equivalent to those from whole milk.