Relationships Between Lard Production Methods, Volumes Of Production, Costs and Characteristics of Lard Produced in Selected Packing Plants

by E. S. Clifton, Joseph Kastelic and Belle Lowe

Department of Economics and Sociology
Department of Animal Husbandry
Department of Food and Nutrition

Agricultural Marketing Service,
United States Department of Agriculture
cooperating

AGRICULTURAL EXPERIMENT STATION, IOWA STATE COLLEGE

RESEARCH BULLETIN 432 **OCTOBER, 1955** **AMES, IOWA**

ACKNOWLEDGEMENTS

The Agricultural Marketing Service, USDA, met a major portion of the direct costs of this study through a marketing research contract authorized under the Agricultural Marketing Act of 1946 (Title II). The contract was proposed by the AMS as a facility of its current economic research project on methods and practices in relation to costs in the marketing of animal fats and oils. This report pertains principally to the contract work and findings.

Acknowledgement is made to Harry Doty, Jr., agricultural economist, Donald Jackson, assistant head and C. B. Gilliland, head, Special Crops Section, Marketing Research Division, AMS, for their contributions to the study and for recognizing the need for and initiating these studies.

Acknowledgement is made also to the following persons: Lyle Gaston and William Jackson for conducting the chemical analyses and aiding in the taste panel work, Alma Plagge for collecting some of the taste panel data and Geoffrey Shepherd for his interest and participation in these investigations.

CONTENTS

(Contents continued next page)

(Contents continued)

SUMMARY

The chemical, physical and organoleptic characteristics of commercially produced lard and the costs of producing lard by the open kettle, prime steam and dry rendering methods were examined in this study.

It was observed that several factors may be responsible for variations in characteristics of lard and in costs of rendering lard.

In general, plants using the open kettle rendering method were small plants operating at small volumes of production and using simple processing techniques. These plants were operated at a fraction of their capacity.

The prime steam method of rendering lard was used by plants which produced large quantities of lard, used elaborate processing methods and operated at about 50 percent of their lard rendering capacity.

Plants using the dry rendering method operated at about 60 percent of capacity. Their average annual production was somewhat less than that for plants using the prime steam rendering method. Several processing steps were involved in producing lard by the dry rendering method.

These variations in volumes of production, complexity of processing procedures and rendering capacities were associated with the methods of rendering the lard considered in this study. Such factors complicate the evaluation of the relationships between methods of rendering, costs of rendering and characteristics of lard produced.

The following observations should be considered in the light of these complications.

(1) The characteristics of the lard samples collected were variable. The lard produced by the open kettle method was the most variable product, and dry rendered lard was the least variable as determined by the chemical and physical data and the taste panel's evaluation of the lard samples.

(2) There was little consistency between plants in production techniques or treatment of the fat either within rendering processes or between rendering processes.

(3) There was a significant difference in the free fatty acid content of lard samples from different plants using the same method of rendering. The free fatty acid data also indicated that there was a significant difference between samples of lard produced by different methods of rendering.

(4) Lard with a low free fatty acid content, high smoke point, high stability, etc., was produced (in some plants) by each of the three methods of rendering lard.

(5) The smoke point was closely related to the free fatty acid content of the lard.

(6) The relationship between shelf life and the stability tests (AOM) was not clear cut.

(7) The addition of an antioxidant to the lard samples increased the stability of the product.

(8) The dry rendering method gave a product having the lowest free fatty acid content and the least variation in the chemical and physical characteristics of the lard.

(9) The open kettle method had the largest average cost of production. The prime steam method ranked second, while the dry rendering method was the cheapest method of producing lard.

(10) The largest cost item was the cost of packaging materials. The many sizes, shapes and kinds of containers used to package lard accounted for a major portion of the differences in packaging costs between plants (the cost of the raw product was not considered in this study).

(11) The second largest single cost item studied was the labor cost. The greatest source of variation of costs (other than packaging costs) between the different methods of rendering lard was attributable to labor costs.

INTRODUCTION

A 230-pound market hog will produce a dressed carcass weighing about 160 pounds, of which fat trim accounts for about 43 pounds. The fat represents about 27 percent of the weight of the dressed carcass. Much of this fat is rendered into lard. Since lard is a joint product with meat in pork production, changes in the price of lard influence the price of hogs. Over 40 percent of the income of Iowa farmers is derived from the sale of hogs. Therefore, any change in the demand for lard will affect a large segment of the agricultural economy.

One way to increase the demand for food products is to improve their quality. Lard is not an exception.

Several factors have been responsible for the deterioration of the competitive position of lard in the domestic and foreign fats and oils market. Some of these factors are:

(1) Technological advances which have made possible the manufacture of cooking fats from readily available and relatively cheap vegetable oils.

(2) The complexity of vegetable oil manufacture into shortenings has encouraged standardization of the product produced, because elaborate control of processing (i.e., decolorizing, deodorizing, hydrogenation, etc.) is required. These requirements prohibit small-scale manufacturers. Lard, on the other hand, is produced in many plants by simple batch operations demanding no special skills or technical knowledge. As a consequence, the quality of the lard produced quite often is variable.

(3) In contrast to lard, shortenings made from vegetable oils have been processed and standardized to meet specific culinary uses to encourage their consumption.

(4) There has been a tremendous increase in the world supply of vegetable oils in the last 20 years.

These developments clearly show that, if lard is to maintain or improve its competitive position as a food fat, it must possess quality characteristics equal to or superior to vegetable shortenings. Specifically, such a product must be fabricated for special culinary uses, uniform in quality and stable (maintain its quality during storage at room temperatures).

Furthermore, these quality attributes must be attained at a relatively small production cost.

These are the considerations which prompted the investigations reported in this bulletin.

Relationships Between Lard Production Methods, Volumes Of Production, Costs and Characteristics of Lard Produced in Selected Packing Plants[1]

BY E. S. CLIFTON, JOSEPH KASTELIC AND BELLE LOWE[2]

OBJECTIVES OF THE STUDY

The specific objectives of this study are:

(1) to investigate the characteristics of the lard being produced as measured by chemical, physical and organoleptic tests;

(2) to determine which production techniques are associated with these characteristics;

(3) to investigate the costs of producing lard by different methods and techniques of rendering lard; and

(4) to relate these costs to certain characteristics of the product.

It is assumed that certain characteristics of lard are desirable. They are: (1) long shelf life, (2) low free fatty acid content, (3) high smoke point, (4) absence of off color, (5) absence of off flavors and (6) absence of off odors.

Although no attempt was made in the study to set out the specific amounts or combinations of these characteristics necessary to produce lard of a given quality, it is assumed that a lard with a high rating on each of the above points would be a better product (higher quality) than a lard which rated low on each of these counts.

Some minimum standards for acceptable lard have been suggested as follows:[3]

Lovibond red — 2.0 as a maximum
Free fatty acid — 0.2 percent as a maximum
Smoke point — 375° F. as a minimum.

The results of these investigations are presented in four sections: Section A. Characteristics of plants selected, Section B. Characteristics of commercially produced lard, Section C. Costs of producing commercially produced lard and Section D. Discussion and general observations.

SECTION A. SOURCE AND CHARACTER OF THE DATA[4]

PLANTS INCLUDED IN THE STUDY

Plants were selected to facilitate investigations of current processing methods of lard rendering, the characteristics of lard produced and the cost of producing lard by each of the three major rendering methods.

Except when stated otherwise, the plants selected for this study are located in Iowa.

PRIME STEAM PLANTS

All plants producing lard by the prime steam method in Iowa were included in the original sample. Operators of four plants agreed to cooperate and these plants were included in the study.

DRY RENDERING PLANTS

Plants outside of Iowa were included to obtain data on the dry rendering method since at least three plants were needed.

OPEN KETTLE PLANTS

There were approximately 51 packing plants in Iowa using the open kettle method of rendering lard when this study was conducted. To obtain plants of varying volumes of production using this method of processing lard, a survey of the annual production of each plant was made for 1951.

The production figures were used to separate the plants into four size categories — very small, small, medium and large.[5]

Three plants were selected from each of these four groups. The plants were selected at random, but in many cases the operators of plants selected either were not interested in this study or had in-

---

[1] Project 1209, Iowa Agricultural Experiment Station. Data were collected under a contract with the Special Crops Section, Marketing Research Division, AMS, USDA.

[2] Assistant professor of economics and sociology, associate professor of animal husbandry (meats) and professor of food and nutrition, respectively.

[3] Harlan, Daniel D. Lard marketing as affected by commercial processing methods. USDA, PMA Agr. Inf. Bul. 53. June 1951. pp. 32-34.

[4] A plant using more than one method of processing fats was counted as two plants. Since there were 17 plants included in the study and two produced lard by two methods, the total number of processes studied was 19. For simplification, each of these is considered as a plant in this study.

[5] These terms are relative, and a large kettle operation could easily be smaller than a small dry rendering or prime steam operation.

adequate records. Another plant was selected at random to replace each unsatisfactory plant originally selected.

The selected plants produced about 75 percent of the lard produced by the prime steam method of rendering, all of the lard produced by the dry rendering method and about 30 percent of the lard produced by the open kettle method of rendering in Iowa during the period studied. Thus, the data from the selected plants should be fairly representative of the lard produced in Iowa.

However, it should be noted that if state totals were to be computed from the data presented in this manuscript, it would be necessary to weight the data by the inverse of the selection rate. Even then the data would be inaccurate to the extent that non-cooperating plants differ from cooperating plants. Because of this limitation and since this study was designed as a case study, state totals are not included.

Equipment Used in Plants Selected

The amount and kinds of equipment used by different plants using the same processing method was extremely variable. Suggested plant layouts and floor charts are shown in figs. 1, 2 and 3 for the open kettle, dry rendered and prime steam methods of rendering lard, respectively.

The equipment shown in figs. 1, 2 and 3 are for lard production only. Refining equipment such as hydrogenation equipment is not shown. The plant flow charts for the different processes are very much alike except for the method of extracting the lard from the raw fat.

These flow charts show the quantity of equipment usually considered necessary to produce a quality lard product. They do not necessarily represent the plants in this study. In general, the open kettle plants had much less equipment than is shown in fig. 1 while the other two processes involved more equipment than is shown in figs. 2 and 3.

The quantity and age of the equipment is discussed briefly because this equipment may have some effect upon the quality characteristics of the lard and obviously will have some effect on the costs of production. Furthermore, such a discussion will show the heterogenity of the processing steps used in producing the lard and give some indication of the processing steps used by different methods of rendering and different sized firms.

OPEN KETTLE

The standard equipment used in practice by the plants producing lard by the open kettle method include: an open kettle, a settling tank and a water cooled agitator tank. Two exceptions to this were the two large plants which used the open kettle process for rendering a special type of lard. These plants had about the same equipment as shown in fig. 1. Most of the open kettle plants also had a hand operated, hydraulic crackling press. Additional information relative to the equipment and processing steps is shown in tables 1 and 2.

Most of the equipment used in these plants had been used 15 years or more. Since the usual size kettle is about 100 gallons (they varied in capacity from 75 to 250 gallons) and 11 batches of lard could be produced per week, the productive capacity of this machinery would be about 5,000 pounds of lard per week. These plants, however, usually operated the lard department either 1 or 2 days per week and rendered one batch of lard per day. Thus, the equipment was used to only a small fraction of capacity.

DRY RENDERING

The quantity of equipment used by the firms using the dry rendering process was much larger than for the open kettle method. All plants used

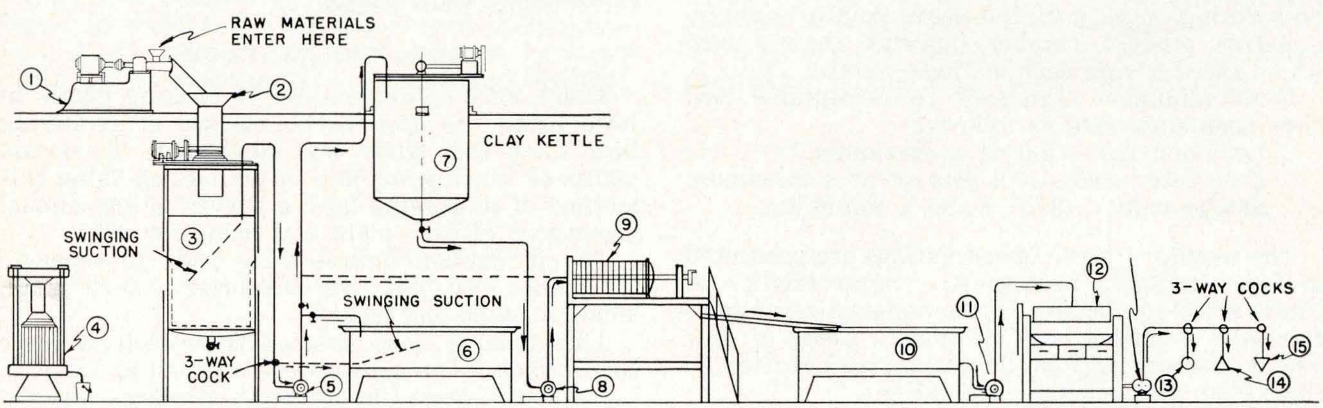

FIG I. SUGGESTED PLANT LAYOUT AND FLOW DIAGRAM FOR OPEN KETTLE LARD RENDERING PLANT.

1. FAT GRINDER.
2. CHARGING CHUTE TO JACKETED AGITATOR KETTLE.
3. JACKETED AGITATOR KETTLE.
4. HYDRAULIC LARD PRESS.
5. ROTARY PUMP.
6. LARD RECEIVING AND SETTLING TANK.
7. CLAY MIXING KETTLE.
8. ROTARY PUMP.
9. FILTER PRESS.
10. TANK WITH STEAM COILS.
11. ROTARY PUMP.
12. LARD COOLING ROLL.
13. LARD FILLING MACHINE FOR CARTONS.
14. BELL FILLER FOR TUBS.
15. PEAR FILLER FOR TIERCES.

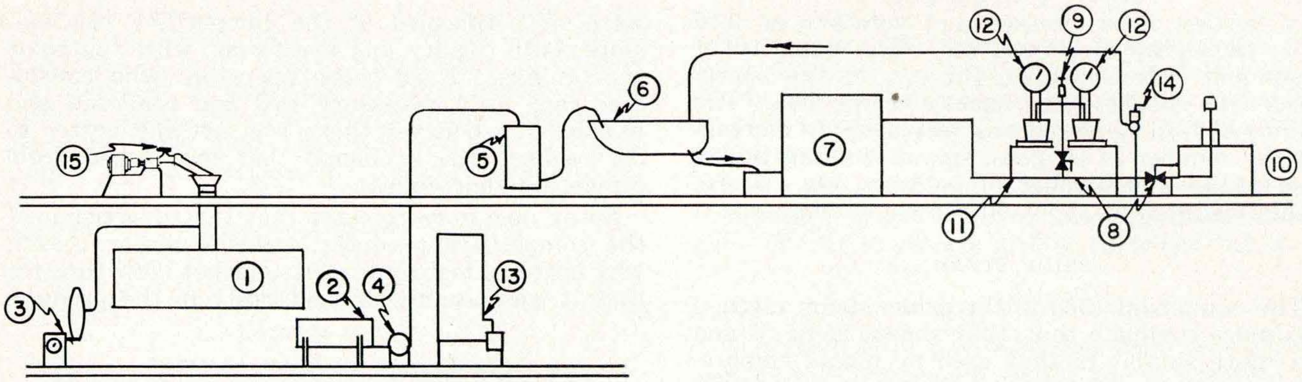

FIG. 2. SUGGESTED PLANT LAYOUT AND FLOW CHART FOR A DRY RENDERING LARD.

1. DRY RENDERING COOKER.
2. PERCOLATOR.
3. VACUUM PUMP FOR COOKER.
4. LARD PUMP.
5. FILTER.
6. LARD HOLDING TANK.
7. "VOTATOR" WITH PUMP.
8. $1\frac{1}{4}$" IRON STOP COCK.
9. NOZZLES FOR FILLING TUBS, TIERCES, ETC.
10. FOOT-OPERATED FILLING MACHINE, 1 TO 5 POUNDS.
11. LARD PACKING TABLE.
12. LARD SCALE FOR CANS AND TUBS.
13. HAND-OPERATED HYDRAULIC CRACKLING PRESS.
14. PRESSURE RELIEF VALVE.
15. FAT GRINDER.

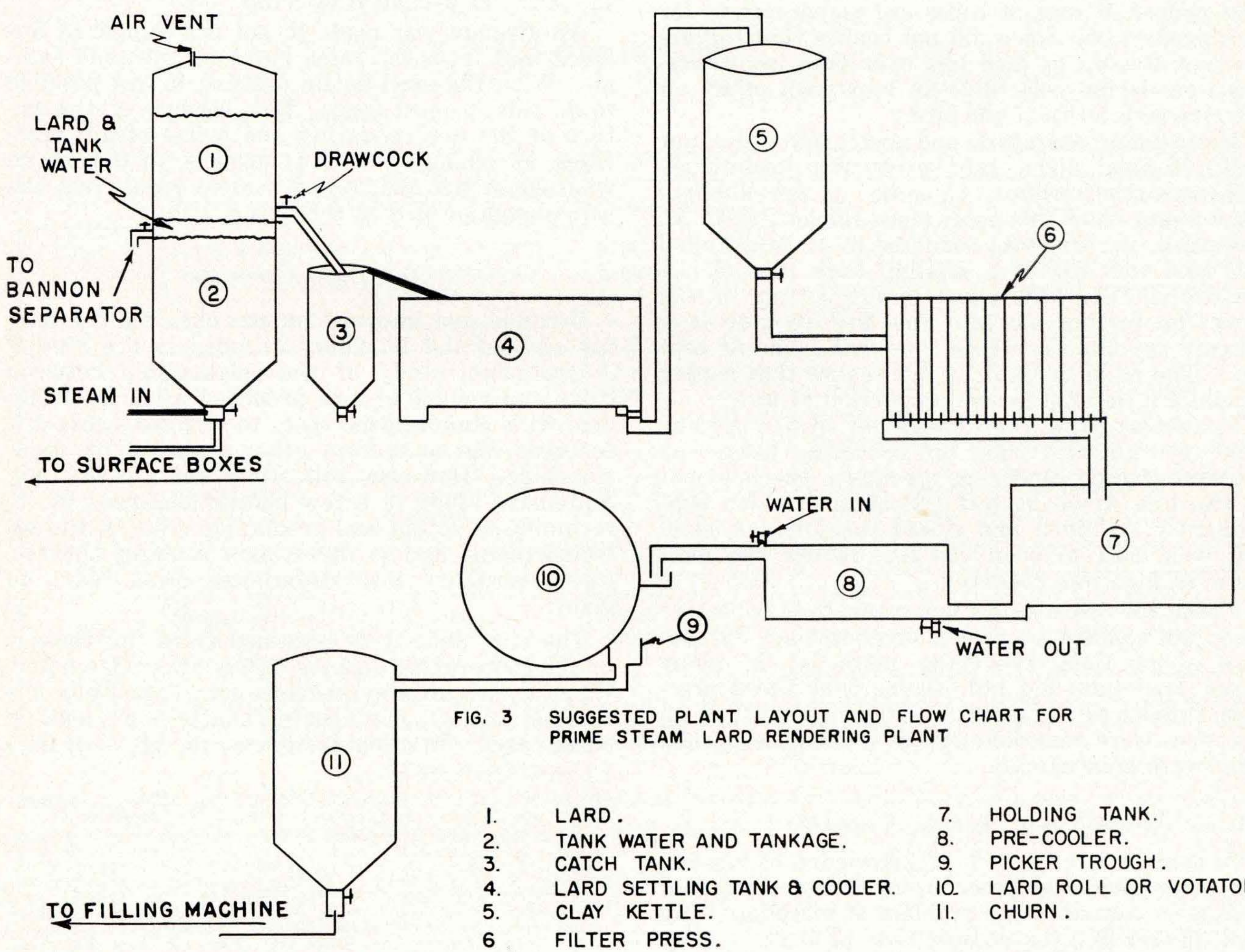

FIG. 3 SUGGESTED PLANT LAYOUT AND FLOW CHART FOR PRIME STEAM LARD RENDERING PLANT

1. LARD.
2. TANK WATER AND TANKAGE.
3. CATCH TANK.
4. LARD SETTLING TANK & COOLER.
5. CLAY KETTLE.
6. FILTER PRESS.
7. HOLDING TANK.
8. PRE-COOLER.
9. PICKER TROUGH.
10. LARD ROLL OR VOTATOR.
11. CHURN.

clay kettles, filter presses and votators or lard rolls, packaging machines, etc. The quantity of equipment depended upon the size of the operations. The cookers were usually of one size. The volume of lard rendered was increased by increasing the number of cookers, size of holding tanks, clay kettles and number of votators, etc. These plants operated at about 60 percent of capacity.

PRIME STEAM

The equipment used in the prime steam method was more complete than that shown in fig. 3 and was quite similar to that used by plants employing the dry rendering method of rendering lard. However, tanks were substituted for cookers in the steam rendering process. Prime steam rendering plants operated at about 50 percent of capacity.

Other Observations

LACK OF KNOWLEDGE

Some operators were not familiar with the factors affecting the production of a "quality" lard. In several cases, little was known about the effects treatment of the fat before rendering had on the characteristics of the finished product. Operators of some of the lard departments were not aware that copper fittings or tubes are inappropriate for lard production. Some did not realize that mixing a small amount of lard left over from some previous rendering may have an important effect on the characteristics of the lard.

Many plant operators and employees were not well informed about lard production techniques and their relationships to quality. A few illustrations might show this point more emphatically. At one plant, the lard was rendered in a conventional way and was run in a settling tank to cool. A perforated tube was coiled in the bottom of the tank for forcing air into the lard to give it a creamy appearance. This tube was made of copper. The plant operator didn't realize that copper should not be used in the production of lard.

In another plant, there was a low spot in the line used to drain lard from the rendering tank. At the end of each rendering operation, the low spot in the line would be left full of lard which subsequently solidified and closed the line. A steel rod was used to open the line before the next batch of lard was rendered.

These illustrations do not mean that operators were not quality conscious or that they did not care about their rendering methods; in many cases, they just did not realize that these practices influenced the quality of their product. Such practices were remedied almost immediately when they were pointed out.

QUALITY AND SELLING KNOWLEDGE

In contrast to the lack of knowledge of rendering techniques and procedures, almost all managers were aware of the problem of merchandising lard in relation to competitive products. They were well informed of the competitive relationships, both quality and price-wise, with vegetable shortenings. Even those operators who considered lard as a necessary evil and rendered and handled it whenever there was nothing better to do, realized the problems that lard faced from competing shortenings.

Many operators thought that the advertising of the competitive products was the major reason why lard had lost some of its market. Few thought that it was because of variability in the product.

Selection of Lard Samples

The samples of lard collected were obtained in the following manner for each of the methods of rendering lard.

The first sample was collected from the settling tank immediately after being drained from the rendering tank, cooker or kettle into the settling tank. This was done by agitating the lard and dipping 2 to 3 pounds out of the tank. This lard was placed in a clean 5-pound pail. The second lard sample was collected when the product was being packaged. Two to 3 pounds of the lard were obtained from the packaging machine or from the agitator tank during the packaging operation if the lard was packaged by hand.

An attempt was made to get the sample of finished lard from the same batch as the tank sample. With the open kettle process, it was possible to do this in most cases. But, because of the nature of the dry rendering and prime steam processes, it usually was not possible to determine whether or not the second sample came from the same batch of lard as the first.

Cost Data Obtained

Detailed cost information was obtained for 1951 for each of the 17 plants included in the study.[6] A statistical study of the relationship between costs and volume of lard produced would probably deal with standardized costs to eliminate cost differences due to factors other than volume relationships.[7] However, this study was a case study (intensive study of a few plants) designed to determine the actual lard production costs in the selected plants and to investigate some of the factors associated with differences from plant to plant.

The cost data were obtained from the records of the cooperating packers unless otherwise noted. When the records were inadequate (usually in the smaller plants), manager estimates were used in some cases. In other instances, the physical data

[6] Since two plants processed lard by two different methods, there are 19 processing costs computed (see footnote 4).

[7] For a discussion of standardization of costs see: Homme, Henry A. Estimation and use of cost functions in Iowa creameries. Jour. Farm Econ. 35:931-937 1953; Frazier, U. R., Nielsen, V. H. and Nord, J. D. The cost of manufacturing butter. Iowa Agr. Exp. Sta. Res. Bul. 389, pp. 800-801; and Wiegmann, Fred H., Clifton, E. S. and Shepherd, Geoffrey. Comparison of costs of service and self-service methods in retail meat departments. Iowa Agr. Exp. Sta. Res. Bul. 422.

were obtained by measuring the quantity of labor, water, steam, etc., used in rendering specific quantities of lard. Items of cost were selected as the result of a pre-study of three plants to determine what records were available and what classifications could best be used for the cost items. This cost classification was revised slightly during the course of the investigation so as to be applicable to all plants studied.

Experimental

Lard Samples

Samples of 2 to 3 pounds of lard were collected from 16 plants approximately every 60 days for 1 year.[8]

Storage of Samples

After collection, the samples were taken immediately to the laboratory and put into a cooler held at a temperature of 2° to 4° C. The containers were removed from the cooler for short periods of time when subsequent samplings were made for the various tests.

[8] After this study was initiated, one plant discontinued killing hogs, so no lard samples were collected.

Number of Samples

There were 181 samples of lard collected. Of these, 86 were rendered by the open kettle method, 48 by the prime steam process (an additional 12 were rendered pork fat) and 35 were dry rendered samples.

The techniques and methods of analysis used to obtain physical, chemical and organoleptic data used in this study are briefly described below.

Organoleptic Tests

The samples of lard collected were scored by a panel of six people who rated the samples on the basis of color, odor, flavor, texture and consistency (see lard score card).

(1) The lard was taken from original containers and placed in clean, dry ½-pint jars which had been rinsed in distilled water before drying. The lids were covered with waxed paper circles, thus preventing the lard from coming in contact with the metal. Separate spoons were used to transfer lard from each container to the ½-pint jars.

(2) Samples were scored after tempering to 25° to 26° C.

(3) The panel members indicated their score by

Lard Score Card

NAME ____________________

Sample No* ______________

Date ______________

	10	9	8	7	6	5	4	3	2	1
	Excellent	Very good	Good	Above average	Average	Below average	Fair	Poor	Extremely poor	Unacceptable
Odor	Mild, pleasing odor.		Mild, no odor or practically odorless.		Slight off odor. Suggestion of burnt odor.		Strong off odor, pungent, acrid, rancid, burnt, strong.		Very strong, disagreeable off odors. Sharp, strong, rancid odor.	
Flavor	10	9	8	7	6	5	4	3	2	1
	Mild, pleasing flavor.		Mild to flavorless.		Slight off flavor, acrid.		Burnt flavor, pungent, sharp, bitter, salty, strong, rancid.		Very rancid. Strong off flavor, bitter, sharp, strong.	
Color	10	9	8	7	6	5	4	3	2	1
	Creamy white to white.		Very white, opaque, bluish tint.		Bone white, blue white.		Brownish tinge, reddish tinge, yellowish tinge.		Marked blue or green color.	
Texture †	10	9	8	7	6	5	4	3	2	1
	Small crystals, homogeneous or large crystals, homogeneous.		Very fine crystals, homogeneous, "satiny" smooth.		Medium size crystals, homogeneous, no separation.		Medium size crystals, some greasiness.		Coarse crystals, separation or lack of crystals, breaks off short.	
Consistency †	10	9	8	7	6	5	4	3	2	1
	"Tacky," above average firmness.		Very firm, waxy, apt to crack and snap when stirred.		Soft, hard to handle, greasy.		Very soft, very difficult to handle.		Very soft, oily or gummy, rubbery.	

* Always score samples in order given and check descriptive term with each score given, add new terms if you wish.

† Data from these categories were not used because of the manner in which the samples were collected and let cool.

checking the score value and the appropriate descriptive terms and by adding descriptive terms of their own. The use of new terms was encouraged. The scores and terms were recorded in a separate notebook and evaluated so that the results of an individual might easily be checked. The lard remaining in the jar was weighed out in 85.5 gram portions and placed in a storage cabinet held at 29° to 31° C. for the shelf life stability studies.

CHEMICAL TESTS

Free fatty acid was determined by AOCS Official Method CA 5a-40 and calculated as percent oleic acid. The only deviation from this procedure was that the sample was not liquified before the aliquot was taken for the determination.

Smoke point was determined by AOCS Official Method Cc 9a-48.

Wiley melting point was determined by AOCS Official Method Cc 2-38.

Refractive index was determined by AOCS Official Method Cc 7-25. The values were corrected to 40° C. by the experimentally determined equation:

$$\frac{dn}{dt} = 0.004 \text{ (per° C.)}$$

Wesson color was determined by AOCS Official Method Cc 13b-45. A 2⅝-inch column was used throughout the work. The Lovibond glasses were not standardized.

Stabilities were determined by the Swift stability test as modified by Reimenschneider, Turer and Speck[9] with regard to the use of an all-glass, single-tube determination. The procedure differed slightly in that H_2SO_4 was used to dry the air after it came from the permanganate wash. A bottle was placed just before the manifold to trap any H_2SO_4 that might be mechanically carried over. The stainless steel manifold and steam-heated oil bath was a modification of Bates' apparatus.[10] The special pressure release valve and air washing and metering devices were not used.

Peroxides were determined by Lea's method[11] in the following manner: Acetic acid (CP) was refluxed for 2 hours with acetic anhydride and then distilled. The fraction boiling at 115.5° to 116.5° C. (uncorrected) was collected. Mallinckrodt's A. R. chloroform was used without any further purification. Baker's or Baker and Adamson's reagent potassium iodide was not used if it gave an appreciable value in the blank titration. Twelve ml. of acetic acid were measured into a 125 ml. Erlenmeyer flask. The acetic acid was deoxygenated with nitrogen for 15 minutes. Ten ml. of chloroform and 1.2 ml. of potassium iodide solution (12 g. KI plus 15 ml. water) were added and the deoxygenation continued for an additional 5 minutes. A 15-inch air condenser was put into the flask. The flask was immersed into boiling water until the solution boiled. The condenser was removed and the sample (about 1 gram) was added by means of a syringe. The weight of the sample of fat was determined by weighing the syringe and fat on an analytical balance before and after a portion of the fat was transferred from the syringe to the reaction flask. The condenser was replaced and the flask was put into a 77° C. water bath for 2 minutes. Fifty ml. of water and 2 ml. of 1-percent starch solution were added. The titration (with standard $Na_2S_2O_3$) was carried out under nitrogen using a magnetic stirrer for agitation.

Iodine numbers were determined by the Rosenmund-Kuhnhenn method.[12] The excess reagent was titrated with standard $Na_2S_2O_3$.

Spectrophotometric color was determined by AOCS Tentative Method Cc 13c-50 (revised Oct. 1951) with the following modification: An Evelyn colorimeter was used throughout the work. The percent transmission was read with 470, 550, 620 and 660 filters. The photometric color was determined by the following formula: photometric color $1.29D_{470} + 69.7D_{550} + 41.2D_{620} - 56.4D_{660}$. The colorimeter gave the following standardization against Ni_2SO_4: 420mμ = 17.25%; 470mμ = 62.25%; 515mμ = 77.0%; 550mμ = 65.25%; 620mμ = 13.0%; 660mμ = 4.25%.

CHEMICAL: ADDITIONAL NOTES ON THE EXPERIMENTAL PROCEDURES

In the determination of the free fatty acid content, the whole sample was not melted because every time the lard was melted its stability decreased.

In determining the Wesson color, 2 ⅝-inch columns were used instead of the usual 5 ¼-inch column because yellow glasses beyond 2.2 and red glasses beyond 1.0 were not available.

In the peroxide determination, a saturated solution of potassium iodide was not used because the chloroform precipitated the potassium iodide when the solution was more concentrated than 12 g. KI in 15 ml. of water. Fifteen minutes deoxygenation of the acetic acid was necessary to remove all the dissolved oxygen and thus assure a zero blank correction. Nitrogen flushing readily removed dissolved oxygen from the chloroform because of the low solubility of oxygen in chloroform. Ten ml. of chloroform were used instead of the normal 8 ml. because the 5 minutes of nitrogen flushing distilled out about 2 ml. of the chloroform. When all the reagents were carefully prepared, corrections for the blanks were not required.

Consistency measurements by the penetration method were discontinued early because the samples received were not cooled and solidified in the same manner as the lard in the plants. This did not permit the lard to form its usual crystalline

[9] Oil and Soap 20: 169-71. 1953.
[10] Jour. Amer. Oil Chem. Soc. 25: 42-44. 1948.
[11] Soc. of Chem. Ind. 65: 286-91 1946.
[12] Z. Nahr. Genussm. 46: 154-9. 1923; cf. C. A. 18: 477. 1924.

TABLE 1. USUAL PROCESSING HISTORY OF LARD (CLASSIFIED BY PLANTS).

Plant*	Hours held before rendering	Temperature	Percent fat†			Temperature (°C.)			Time cooked (hrs.)	Pressure (pounds)
			Leaf	Back	Other	Maximum	End	Average		
1	70	35	25	40	35	121	121	93	4	40
2	36	45	20	60	20	122	122	113	7	38
3	100	36	23	48	39	127	121	113	8	35
4	18	34	20	40	40	141	141	116	2	80
5	96	35	20	20	60	138	138	116	6	45
6	3	35	46	10	44	130	130	121	4	60
7	24	45	13	30	57	141	141	141	4	40
8	24	37	28	40	32	138	138	127	3	80
9	44	40	10	70	20	143	143	121	3	75
10	24	33	30	70	00	143	143	116	3	60
11	44	34	12	40	48	132	132	121	3	40
12	24	37	15	30	55	159	159	116	5	80
13	24	36	29	33	38	191	191	177	3	60
14	96	33	60	40	00	116	116	116	3	80
15	72	36	15	50	35	150	150	138	4	40
16	24	32	20	45	35	104	104	104	3	40
17	20	36	90	10	00	104	104	93	2	....
18	20	36	00	44	56	121	93	93	2	....
19	24	40	7	10	83	152	152	152	5	....

* Plants are numbered to avoid identity. Numbers 1 through 12 are open kettle, 13 through 16 are prime steam and 17 through 19 are dry rendered.

† The percentages of the different types of fats that were put in the rendering tank or kettle were estimates of the person in charge of the lard department.

structure. Thus, tests of consistency by physical methods and by the taste panel were not considered useful.

Moisture determinations were not made for two reasons. First, all of the approved AOAC procedures measure volatile material and are not specific for water. The Karl-Fisher titration could have been used. Second, most of the samples were poured hot and allowed to stand until solidified. During the cooling of the lard, the water settled toward the bottom of the can. Also, every time the samples were removed from the cooler, some moisture collected on the surface of the lard. For these reasons, it was not practical to determine the water content of these samples.

The chemical and physical determinations were done in duplicate. The data shown in the tables are the average values for duplicate determinations.

SECTION B. RESULTS OF ORGANOLEPTIC, CHEMICAL AND PHYSICAL TESTS

Processing History

The processing history of the lard produced by any method of rendering has an important bearing on the results of the organoleptic, chemical and physical properties of the final product.

The processing histories of lard produced by different plants are shown in table 1. The plants are not classified by process. To avoid identification of individual firms, they are listed merely 1, 2, 3, etc.

Table 1 indicates the variation in the way the fat was handled in the different plants. The time that the fat was held before rendering varied from 3 to 100 hours, and the temperature at which the fat was held varied from 32° to 45° F. The per-

TABLE 2. SOME PROCESSING HISTORY OF LARD SAMPLES (CLASSIFIED BY PLANTS).

Plant*	Antioxidant†	Method of cooling	Drying	Lard flakes†	Method of filtering
1	X	Agitation tank	O	O	Cloth strainer
2	X	Settling tank	O	O	Cloth strainer
3	O	Settling tank	O	O	Cloth strainer
4	X	Settling tank	O	O	Cloth strainer
5	X	Lard roll or votator	O	X	Cloth strainer
6	X	Agitation tank	O	O	Cloth strainer
7	O	Agitation tank	O	O	Cloth strainer
8	O	Settling tank	O	O	Cloth strainer
9	X	Agitation tank	O	O	Cloth strainer
10	X	Agitation tank	O	X	Cloth strainer
11	O	Agitation tank	O	O	Cloth strainer
12	X	Settling tank	O	O	Cloth strainer
13	X	Agitation tank	X	O	Cloth strainer
14	X	Votator	X	X	Horizontal
15	X	Votator	O	O	Filter press
16	X	Votator	X	X	Horizontal
17	X	Lard roll	O	X	Filter press
18	O	Settling tank	O	O	Filter press
19	X	Votator	X	X	Centrifuge

* Plants are numbered to avoid identity. Numbers 1 through 12 are open kettle, 13 through 16 prime steam and 17 through 19 dry rendered.

† X, addition to; O, no addition.

TABLE 3. TASTE PANEL EVALUATION OF LARD SAMPLES RENDERED BY PROCESS AND KIND OF SAMPLE.

Sample*	Number of samples	Odor		Flavor		Color		Average	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Open kettle									
1	31	5.7	1.2	5.4	1.2	5.7	1.5	5.6	1.1
2	22	5.4	1.5	5.2	1.5	5.4	1.5	5.3	1.4
3	33	5.1	0.9	5.8	1.1	5.6	1.5	5.8	1.0
Prime steam									
1	22	6.3	1.2	6.1	1.2	7.1	1.4	6.5	1.1
2	2	6.8	—	6.9	—	8.6	—	7.4	—
3	25	6.2	1.2	6.0	1.3	7.7	1.5	6.6	1.2
Dry rendered									
1	15	6.6	1.5	6.6	1.4	7.7	1.2	6.9	1.2
2	6	6.8	—	6.6	—	8.2	—	7.2	—
3	10	7.3	0.9	7.1	0.9	8.3	0.8	7.6	0.7

* Sample 1 is the sample of lard directly from the cooker.
Sample 2 is the sample of lard that was finished but without an antioxidant.
Sample 3 is the sample of lard that was finished and contained an antioxidant.

centage leaf fat of the total fat varied from 0 to 90 percent. The average temperature of rendering varied from 200° to 350° F., and the time that the lard was heated varied from 2 to 8 hours at steam pressures ranging from 35 to 80 pounds.

Eight of the 12 plants which produced open kettle lard added an antioxidant (table 2). These plants did not specifically heat the lard to remove moisture, and only two added lard flakes to the product. An additional three plants added beef tallow to the hog fat during the rendering process to increase the melting point of the lard. Six plants used agitation tanks as a method of cooling. One plant used either a votator or a lard roll for chilling the lard while the rest used settling tanks. Most of the plants using the open kettle process used cloth strainers for filtering the hot lard.

Plants using the dry rendering or prime steam method of rendering added antioxidants to the lard, and all but two of them used a votator or lard roll. Four of the seven plants dried the lard, and four added lard flakes to the product. Cloth strainers were used by only one plant. Bleaching, alkali refining or hydrogenation was not used in the manufacture of lard in any of the plants included in this study, but these processes were used in the manufacture of shortenings other than lard.

Additional information concerning the processing of the fat into lard is contained in Section A relating to equipment used.

Results of the Analyses

The scores for odor, flavor and color (table 3) obtained by organoleptic determinations are discussed in relation to rendering methods used.[13]

OPEN KETTLE

Data were obtained for 31 samples of lard taken directly from the open kettle. This lard did not contain an antioxidant. The average odor score was 5.7 with a standard deviation of 1.2 which is a measure of the variability. The score for flavor was 5.4 with a 1.2 standard deviation. An average score of 5.7 was assigned for color. The standard deviation of 1.5 for color indicates that there was more variation in the color than in odor or in flavor. When the scores for flavor, color and odor were combined, the pooled average score was 5.6 with a standard deviation of 1.1. The 22 samples of lard packaged for sale which did not contain an antioxidant had lower scores for color, flavor and odor than the samples taken directly from the rendering kettle.

There were 33 samples of lard packaged for sale that did contain an antioxidant. The average scores for these lard samples were 5.1, 5.8 and 5.6 for color, odor and flavor, respectively.

Differences in scores between lard samples taken directly from the open kettle and prepared for sale with and without an antioxidant did not appear to be significant.

PRIME STEAM

Twenty-two samples of lard were collected directly from the tanks. These did not contain an antioxidant. These samples had an average odor rating of 6.3, flavor rating of 6.1 and color rating of 7.1. The standard deviation was 1.4 for color and 1.2 for both odor and flavor.

The samples which were packaged for sale and contained an antioxidant had no better scores than the samples taken directly from the tanks. There were only two samples of lard prepared for sale which did not contain an antioxidant.

DRY RENDERED

Fifteen samples rendered by this method were collected from the tanks. They did not contain an antioxidant. These samples were given an average score of 6.6 for odor, 6.6 for flavor and 7.7 for color.

[13] The score sheets were rankings with 10 as the top score denoting absence of color, odor or flavor. The lower the score the more color, odor or flavor the samples had.

TABLE 4. TASTE PANEL EVALUATION OF LARD SAMPLES (CLASSIFIED BY MONTHS AND ANTIOXIDANT).

Property*	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Av.
Odor													
0	6.8	5.7	6.4	8.2	6.6	6.4	6.7	5.1	4.9	7.9	—	5.7	5.9
1	6.7	6.1	6.8	8.0	6.4	7.1	6.1	6.7	4.2	5.2	4.6	5.9	6.1
Flavor													
0	6.2	5.4	6.3	7.7	6.3	6.0	6.1	4.9	4.5	5.3	—	5.8	5.7
1	6.5	5.9	6.4	7.8	5.8	6.8	5.7	6.3	4.1	5.4	5.4	5.9	5.9
Color													
0	7.3	6.3	6.6	7.8	6.4	5.4	8.5	5.6	5.6	6.0	—	7.3	6.3
1	6.3	6.1	7.2	8.5	6.0	9.4	6.5	7.1	4.9	6.2	8.0	7.0	6.6
Average													
0	6.8	5.8	6.4	7.9	6.5	5.9	6.9	5.2	4.9	5.4	—	6.3	6.0
1	6.5	6.0	6.8	8.1	6.1	7.8	6.1	6.7	4.4	5.6	6.0	6.3	6.2

* 0 = those samples without an antioxidant. 1 = those samples with an antioxidant.

Samples of lard rendered by this method and containing an antioxidant had better scores for odor, flavor and color than samples taken directly from the tank. These scores were 7.3 for odor, 7.1 for flavor and 8.3 for color.

Since the samples of lard were collected at different seasons of the year, it was of interest to determine whether there was a relationship between season and taste panel evaluation. To facilitate the analysis, the lard samples were classified as to whether or not an antioxidant had been added. The taste panel's evaluations of odor, flavor and color were categorized according to the months that the lards were rendered (table 4).

The taste panel's evaluation for odor showed a seasonal pattern. The scores for odor ranged from a high of 8.2 in April to a low of 4.9 in September (for samples without an antioxidant). Odor scores for samples containing an antioxidant were also highest in April and lowest in September.

The samples which did not contain an antioxidant were given the highest flavor rating in April (average score of 7.7) and their lowest flavor rating in September (4.5). The same seasonal pattern for flavor scores was observed for lard containing an antioxidant.

For samples which did not contain an antioxidant, the highest average monthly color score was found for samples rendered in July, while the lowest value was observed in samples rendered in June. The lard rendered in April and which contained an antioxidant had the highest color rating whereas samples rendered in September had the lowest color scores. The highest aggregate scores were found for lard rendered in April, and the lowest scores were found for lard rendered in September. Also, the 3 months with which the highest scores were associated were April, May and June, while the lowest scores were associated with the months of August, September and October. In all cases, the scores declined in these months when compared with the other months.

Relationship Between Rendering Method and Chemical and Physical Characteristics of Lard

open kettle

Of the 181 samples of lard collected, 86 were rendered by the open kettle method. Fifty-one of these samples did not contain an antioxidant. The data relative to the free fatty acid content, smoke point, melting point, iodine number, refractive index, Lovibond color, optical density readings, stability (AOM) and shelf life (weeks) are summarized in table 5.

The average free fatty acid content of the kettle-rendered lard which did not contain an antioxidant was 0.47. The standard deviation was 0.65. The samples which contained antioxidant had a somewhat lower average free fatty acid content—0.33. The standard deviation was 0.31.

Although there were variations among samples of lard from the same plant, there was more variation among samples from different plants. This is shown in table 6.

In most cases, the standard deviations of the coefficients were large. When antioxidant was not added, the average stability was 3.3 hours. The

TABLE 5. CHARACTERISTICS OF LARD SAMPLES RENDERED BY THE OPEN KETTLE PROCESS.

Property	Without antioxidant*		With antioxidant†	
	Mean	Standard deviation	Mean	Standard deviation
Free fatty acid (percent oleic)	0.47	0.65	0.33	0.31
Smoke point (°C.)‡	172.0	17.0	183.0	12.0
Melting point (°C.)	36.0	4.0	35.7	3.2
Iodine number	62.1	3.1	63	1.8
Refractive index	1.4601	0.0006	1.4604	0.0005
Lovibond, yellow	5.2	2.2	5.1	1.6
Lovibond, red	1.3	0.6	1.3	0.5
Spectrophotometric color	3.04	1.63	2.95	1.12
Stability (hours)	3.3	8.3	25.0	17.6
Shelf life (weeks)‡	18.8	8.4	45.0	13.9

* 51 samples.
† 35 samples.
‡ Not all samples included in these items.

TABLE 6. VARIANCE OF FREE FATTY ACID BETWEEN PLANTS AND WITHIN PLANTS, OPEN KETTLE RENDERED LARD.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	85	24.898	———
Between plants	12	15.344	1.279
Within plants	73	9.553	0.01309
F = 9.27*			

* Significant, P = 0.01.

average stability of the lard containing an antioxidant was 25 hours.

On the average, the shelf life was 26.2 weeks longer for the samples which contained an antioxidant.

The data for the other characteristics of lard without an antioxidant, which was rendered by the open kettle method, did not appear to be different from those samples which did contain an antioxidant.

PRIME STEAM

There were 48 samples of lard analyzed which were produced by the prime steam method of rendering. Of these, 29 contained an antioxidant. Data similar to those obtained for the open kettle rendered lard are shown in table 7. The average free fatty acid content of the samples which did not contain an antioxidant was 0.30. The standard deviation was 0.11. For the samples which did contain antioxidant, the average free fatty acid content was 0.38 with a corresponding standard deviation of 0.15.

There was more variation in the free fatty acid content between plants than within plants (table 8).

The average stability (AOM) of the lard samples which did not contain an antioxidant was 4.8 hours, and the standard deviation was 4.3 hours. Those samples that contained antioxidants had an average stability (AOM) of 20.6 hours with a standard deviation of 15.7. The shelf life for samples containing an antioxidant was almost 17 weeks longer than for samples which did not contain an antioxidant. No appreciable differences were observed among the other data recorded in table 7.

Twelve samples of rendered pork fat were analyzed. They were rendered by the prime steam method and did not contain an antioxidant. The average free fatty acid content of the samples was 0.54. The standard deviation was 0.29 (table 9). The average stability (AOM) of the pork fat was 1.8 hours with a corresponding standard deviation of 1.8.

DRY RENDERING

Thirty-five samples of lard were collected from plants which used the dry rendering method. Twelve samples contained an antioxidant. The average and standard deviations of the laboratory data are shown in table 10. The average free fatty acid content of samples without antioxidant was 0.19, and the standard deviation was 0.08. For samples which did contain an antioxidant, the average free fatty acid content was 0.22, and the standard deviation was 0.13.

There was more variation in the free fatty acid content of dry rendered lards between plants than within plants (table 11).

The average stability (AOM) of the lard before the antioxidant was added was 0.09 hours. The

TABLE 7. CHARACTERISTICS OF LARD RENDERED BY THE PRIME STEAM PROCESS.

Property	Without antioxidant*		With antioxidant†	
	Mean	Standard deviation	Mean	Standard deviation
Free fatty acid (percent oleic)	0.30	0.11	0.38	0.15
Smoke point (°C.)‡	172.2	8.5	170.3	9.6
Melting point (°C.)	33.5	3.8	34.9	4.3
Iodine number	63.6	2.5	62.9	2.7
Refractive index	1.4604	0.0004	1.4603	0.0005
Lovibond, yellow	3.2	1.6	3.1	1.2
Lovibond, red	0.7	0.4	0.7	0.4
Spectrophotometric color	2.13	1.25	2.04	0.94
Stability (hours)	4.8	4.3	20.6	15.7
Shelf life (weeks)‡	21.7	6.4	38.3	11.0

* 19 samples.
† 29 samples.
‡ Not all samples included in these items.

TABLE 8. VARIANCE IN FREE FATTY ACID BETWEEN PLANTS AND WITHIN PLANTS, PRIME STEAM RENDERED LARD.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	59	1.3753	———
Between plants	4	0.3202	0.0801
Within plants	55	1.0551	0.0192
$F = 4.17$*			

* Significant, $P = 0.01$.

TABLE 9. CHARACTERISTICS OF RENDERED PORK FAT, 12 SAMPLES.

Property	Mean	Standard deviation
Free fatty acid (percent oleic)	0.54	0.29
Melting point (°C.)	31.3	3.1
Iodine number	65.2	1.9
Refractive index	1.4602	0.0005
Lovibond, yellow	3.1	1.2
Lovibond, red	0.7	1.4
Spectrophotometric color	2.10	0.91
Stability (hours, AOM)	1.8	1.8

TABLE 10. CHARACTERISTICS OF LARD RENDERED BY THE DRY RENDERING PROCESS.

Property	Without antioxidant*		With antioxidant†	
	Mean	Standard deviation	Mean	Standard deviation
Free fatty acid (percent oleic)	0.19	0.09	0.22	0.13
Smoke point (°C.)‡	186.6	7.3	195.4	11.8
Melting point (°C.)	35.1	3.3	44.7	4.8
Iodine number	62.9	2.3	59.2	1.8
Refractive index	1.4603	0.0007	1.4603	0.0006
Lovibond, yellow	2.8	1.0	3.1	0.7
Lovibond, red	0.6	0.4	0.8	0.3
Spectrophotometric color	1.50	0.52	1.71	0.96
Stability (hours)	0.9	0.8	19.6	12.1
Shelf life (weeks)‡	15.6	12.2	43.6	11.2

* 23 samples.
† 12 samples.
‡ Not all samples included in these items.

TABLE 11. VARIANCE IN FREE FATTY ACID CONTENT BETWEEN PLANTS AND WITHIN PLANTS, DRY RENDERED LARD.

Source of variation	Degrees of freedom	Sums of squares	Mean square
Total	34	0.3362	———
Between plants	2	0.2047	0.1024
Within plants F = 24.92*	32	0.1315	0.0041

* Significant, P = 0.01.

samples which contained an antioxidant had an average stability (AOM) of 19.6 hours and a standard deviation of 12.1 hours. The shelf life was 28 weeks longer for the samples which contained an antioxidant than for those which did not.

The antioxidant-containing lards produced by dry rendering had somewhat higher smoke points and melting points and lower iodine numbers than similarly rendered samples of lard not containing an antioxidant.

Seasonal Variations in Lard Characteristics

Since there is some evidence that environment may influence the composition of fat in the pig, the relationships between the characteristics of lard and the season were examined. The average values of the data for lards with and without antioxidants were categorized by months (table 12).

The values for the free fatty acid content of lard without antioxidant were used in preparing graphs. The average of the free fatty acid content of the samples was fairly high in January, February and March (fig. 4). It dropped during the spring months of April, May and June, started to rise in July, reached a peak in August and September and dropped in October, November and December.

Individual sample values for four plants were selected to determine if there was a general pattern of seasonal effects by plants not apparent in the average analysis. To avoid disclosure of data from individual plants, these data are not presented. The data from these plants did not show a consistent seasonal pattern for the free fatty acid content of the lard, nor did the free fatty acid content, when classified by method of rendering, show any significant relationship to the time of year of rendering.

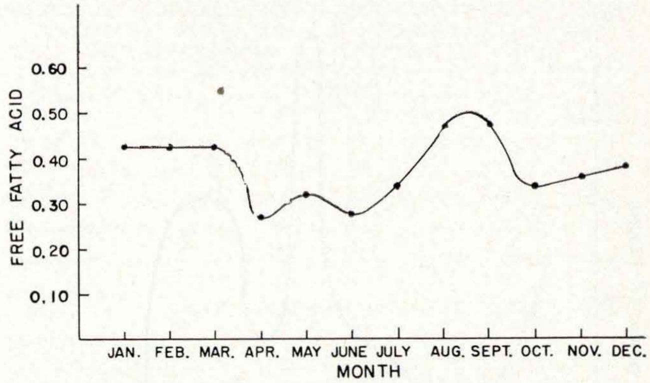

Fig. 4. Seasonal variation of free fatty acid content of samples of lard.

The seasonal variations with respect to stability for all lard samples which did not contain an antioxidant are shown in fig. 5. The stability values were fairly high in January, dropped in February and March, started to rise in April, continued to rise in June, and leveled out for July, August and September, then fell sharply in October, November and December.

The average Lovibond red color was about 1.0 for the first 3 months of the year; it dropped somewhat during April, May, June and July, increased to the peak in August and then dropped to the original level of about 1.0 for the last 3 months in the year (fig. 6).

No clear cut seasonal pattern is apparent in the data for the remaining chemical and physical

TABLE 12. SEASONAL VARIATION OF THE PROPERTIES OF LARD (CLASSIFIED BY WHETHER OR NOT AN ANTIOXIDANT WAS ADDED).

Chemical property*	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Number of samples												
0	7	15	19	1	18	3	4	12	11	14	1	11
1	6	6	13	1	8	3	3	4	6	8	1	5
Lovibond, yellow												
0	5.4	6.1	3.8	2.1	3.5	2.8	3.3	5.4	4.3	4.2	5.2	3.9
1	4.3	5.5	3.7	2.1	4.7	4.1	3.0	3.7	4.1	4.1	2.1	5.6
Lovibond, red												
0	1.1	0.8	1.2	0.6	0.9	0.6	0.7	1.5	1.0	1.1	1.0	1.0
1	1.0	1.1	0.9	0.6	1.1	0.7	0.7	0.8	1.1	1.2	0.2	1.1
Spectrophotometric												
0	3.05	2.04	2.96	1.91	2.00	1.41	1.76	3.67	2.34	1.98	2.68	2.21
1	2.60	2.16	2.60	1.92	2.96	1.68	1.56	2.18	2.35	2.19	1.59	2.45
Stability (AOM)												
0	4.9	2.4	1.5	2.5	3.1	9.6	3.1	6.0	5.7	0.7	0.8	1.0
1	25.6	13.6	8.4	18.0	20.3	19.9	16.3	20.2	37.0	26.4	12.0	36.6
Free fatty acid (percent oleic)												
0	0.43	0.43	0.43	0.27	0.32	0.27	0.34	0.47	0.47	0.34	0.36	0.38
1	0.20	0.33	0.25	0.26	0.32	0.43	0.25	0.31	0.51	0.24	0.16	0.36
Melting point (°C.)												
0	32.2	34.2	35.8	31.8	36.8	40.4	34.4	32.7	36.1	35.6	26.6	33.7
1	35.7	34.4	38.1	45.4	38.4	35.0	39.8	33.1	37.0	36.2	39.5	35.5
Iodine number												
0	61.5	62.9	62.4	62.9	62.9	62.4	62.9	62.6	63.9	62.8	68.0	62.8
1	61.6	63.4	62.1	60.3	62.8	62.9	60.0	62.8	62.9	62.0	57.3	62.8
Refractive index												
0	1.4606	1.4602	1.4602	1.4599	1.4599	1.4603	1.4600	1.4600	1.4606	1.4605	1.4608	1.4607
1	1.4607	1.4604	1.4603	1.4599	1.4600	1.4601	1.4604	1.4601	1.4606	1.4604	1.4598	1.4607

* A 0 denotes no antioxidant; 1 denotes with antioxidant.

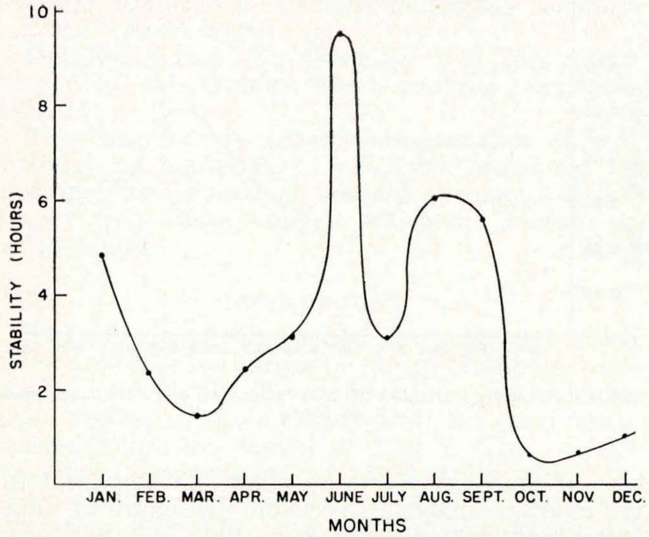

Fig. 5. Seasonal variation in stability, average of samples without antioxidants.

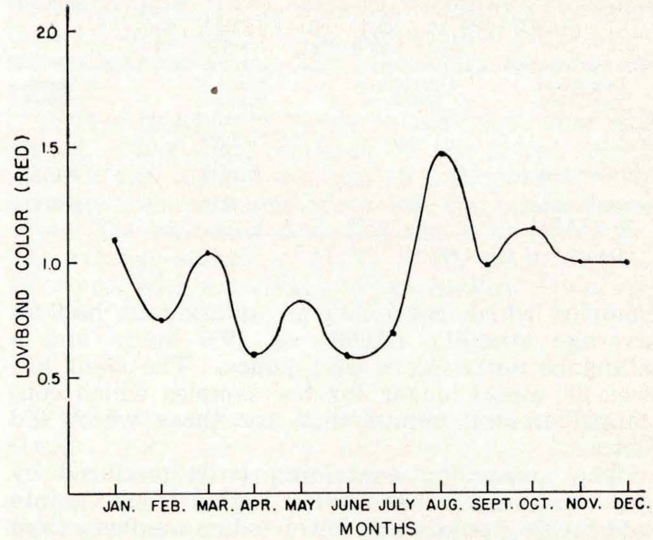

Fig. 6. Seasonal variation of red color, average of samples without antioxidants.

properties of lard (table 12). The data were so variable that seasonal trends, if any, were not apparent.

Characteristics of Lard Produced by Different Methods

A comparison of the organoleptic data of the samples of lard rendered by each of the three methods shows that lard rendered by the open kettle process had the lowest average scores for flavor, odor and color. Prime steam ranked second while dry rendered lard ranked first (table 3).

The samples rendered by the dry rendering process were assigned scores that had the least variation as shown by the standard deviations.

Those data also indicated that dry rendered lards which contained an antioxidant were organoleptically more acceptable, on the average, than lard samples which did not contain an antioxidant.

A comparison of the chemical and physical data of the lard samples rendered by each of the three methods showed differences also. (These comparisons are of samples of lard without antioxidants.)

The rendered pork fat had the highest average free fatty acid content, 0.54 as shown in table 13. The open kettle lard samples contained an average free fatty acid content of 0.47. Prime steam ranked third with an average value of 0.30.

Dry rendered lard contained the lowest amounts of average free fatty acid, 0.19, with a standard deviation of 0.09. Lard produced by the open kettle method was the most variable as shown by the standard deviation of 0.65.

The low standard deviations indicate that there was little variability between the samples of lard produced by the dry rendering method.

The free fatty acid values for open kettle and prime steam lards indicate that the average free fatty acid content was both large and variable.

There was a significant difference in the free fatty acid content of lards rendered by the different processes (table 14). There was, however, more variation in free fatty acid content of lards between plants than within plants.

The lowest average stability (AOM) values were observed in dry rendered lard which did not contain an antioxidant (table 15). The stability values (AOM) of lard containing antioxidants, regardless of how rendered, clearly show the benefit of adding antioxidants. However, there was considerable variability in the stability of the lards after the antioxidants were added. The shelf life of lard containing antioxidants was less variable than the shelf life of lard which did not contain antioxidants.

TABLE 13. FREE FATTY ACID CONTENT (PERCENT OLEIC) OF LARD PRODUCED BY DIFFERENT RENDERING METHODS.

Method of rendering	Without antioxidant		With antioxidant	
	Mean	Standard deviation	Mean	Standard deviation
Open kettle	0.47	0.65	0.33	0.31
Prime steam	0.30	0.11	0.38	0.15
Dry rendered	0.19	0.09	0.22	0.13
Rendered pork*	0.54	0.29	—	—

* Rendered by the prime steam method.

TABLE 14. VARIANCE OF FREE FATTY ACID (PERCENT OLEIC) BETWEEN PROCESSES AND WITHIN PROCESSES OF RENDERING LARD.

Source of variation	Degrees of freedom	Sums of squares	Mean square
Total	180	27.717	——
Between processes	2	1.108	0.554
Within processes	178	26.609	0.149
F = 3.71*			

* Significant at P = 0.05.

TABLE 15. STABILITY (HOURS, AOM), OF LARD PRODUCED BY DIFFERENT RENDERING METHODS.

Method of rendering	Without antioxidant		With antioxidant	
	Average	Standard deviation	Average	Standard deviation
Open kettle	3.32	8.31	25.00	17.58
Prime steam	4.82	4.32	20.62	15.67
Dry rendering	0.86	0.75	19.60	12.08
Rendered pork fat*	1.80	1.75	——	——

* Rendered by the prime steam method.

The stability values obtained by the AOM method and data for shelf life were not closely related (see fig. 5).

The data for smoke point, color and iodine number are shown in tables 5, 7 and 10. The data for lard samples produced by kettle, steam and dry rendering show that smoke point was highest for dry rendered lard samples. The smoke points for lard samples produced by open kettle and prime steam methods were similar. The Lovibond yellow and red color indexes were quite variable; however, the lowest values were observed for lard samples produced by the dry rendering process. Lards rendered by the open kettle method had the highest values for both Lovibond red and yellow (low color values are desirable in lard). The iodine numbers and refractive index of the lard samples were quite similar and did not appear to be influenced by the method of rendering.

The highest melting point was observed for lard which was produced by dry rendering and to which an antioxidant had been added.

The relationships between some chemical, physical and organoleptic characteristics of 172 samples of lard are statistically summarized in table 16. In addition, iodine values were plotted against refractive index as shown in fig. 7. Similarly, fig.

TABLE 16. CORRELATION COEFFICIENTS OF SELECTED CHEMICAL, PHYSICAL AND ORGANOLEPTIC CHARACTERISTICS OF 172 SAMPLES OF LARD.

Characteristic	Odor	Flavor	Lovibond, red	Average*	Free fatty acid†	Stability (AOM)
Odor	1.00	0.87	0.60	——	—0.41	—0.02
Flavor	0.87	1.00	0.67	——	—0.42	—0.04
Lovibond, red	0.60	0.67	1.00	——	—0.42	—0.06
Average*	——	——	——	1.00	—0.42	—0.05
Free fatty acid†	—0.41	—0.42	—0.42	—0.42	1.00	—0.03
Stability (AOM)	—0.02	—0.04	—0.06	—0.05	—0.03	1.00

* Numerical average of scores of odor, flavor and color.
† Percent oleic.

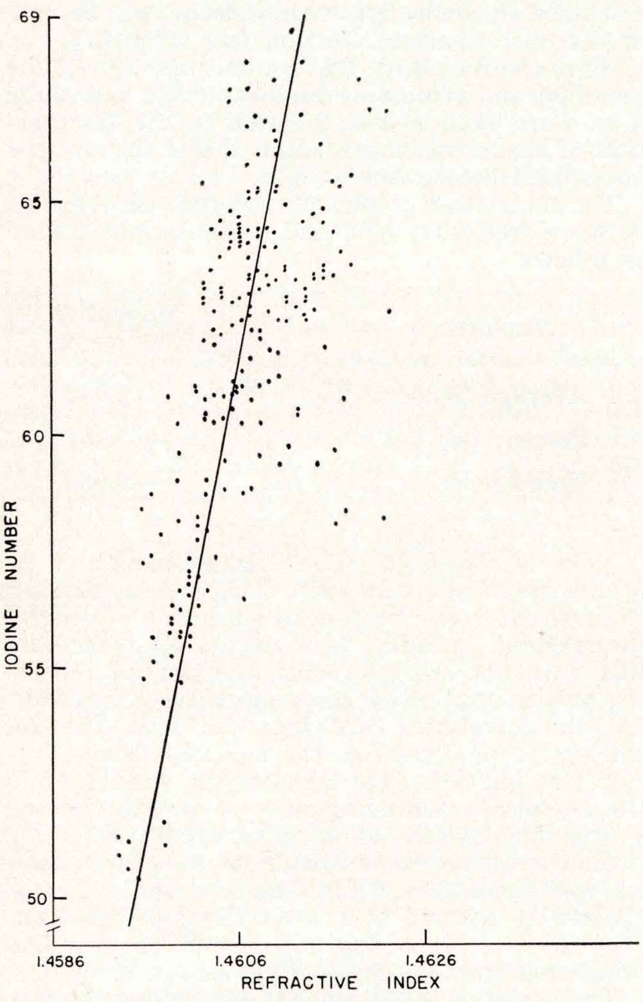

Fig. 7. Relationship between iodine number and refractive index (color).

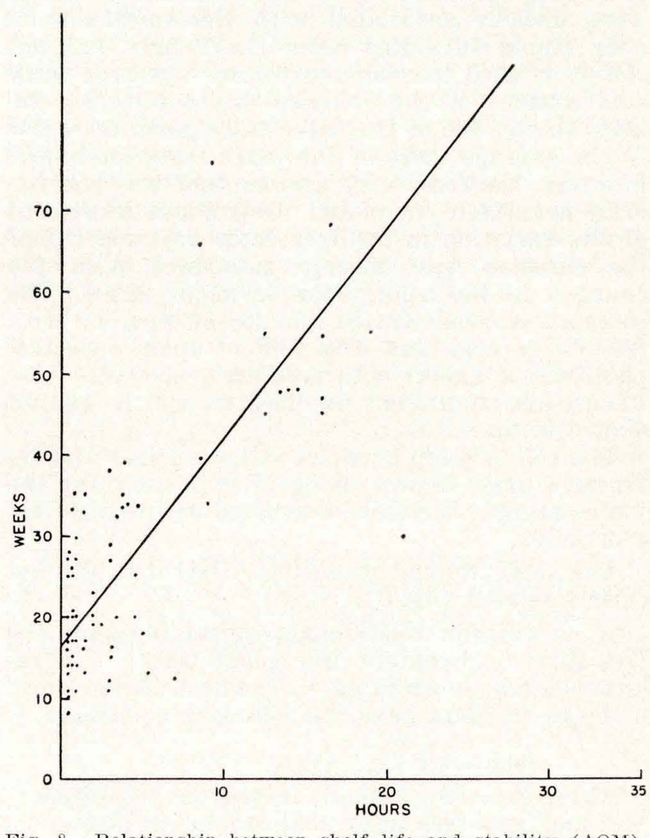

Fig. 8. Relationship between shelf life and stability (AOM), 64 samples.

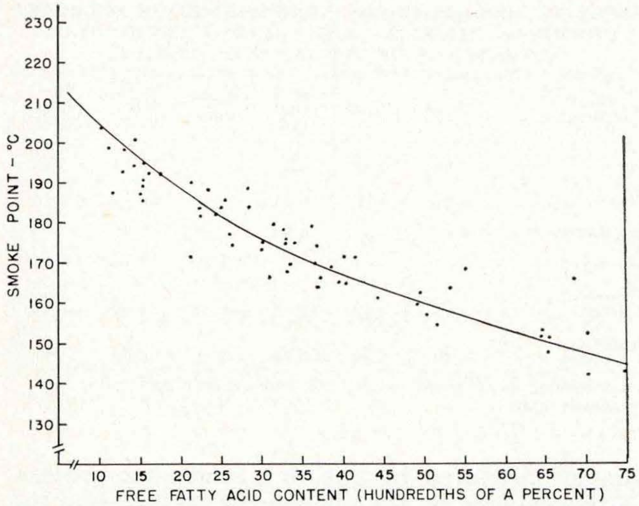

Fig. 9. Relationship between smoke point and free fatty acid content of 80 samples of lard.

8 was prepared to show the relationship between shelf life and stability (AOM). Figure 9 indicates the relationship which existed between the free fatty acid content of the various lard samples and smoke point. The samples not containing antioxidants were used for these figures. Other combinations of data were graphically treated to determine if relationships existed but the relationships were so poor that they are not presented.

It was observed that odor and flavor were closely related. About 76 percent of the flavor scores were linearly associated with the variations in odor (table 16). Red color (Lovibond) was not closely related to odor and flavor. The free fatty acid content of the samples was not closely related to any one of the three taste panel tests nor to the average score of the three tests combined; however, the free fatty acid content was consistently negatively correlated. Only about 18 percent of the variation in the free fatty acid content of the samples was linearly associated with the changes in the color, odor or flavor score. The correlation coefficient of the iodine number with free fatty acid was 0.19 and of color (spectrophotometric index) with free fatty acid was 0.35. (These are additional correlations which are not shown in table 16).

The relationship between iodine number and refractive index shown in fig. 4 indicates that the iodine number is closely associated with the refractive index.

The shelf life and stability (AOM) data are not closely related (fig. 5).

A curvilinear relationship exists between the free fatty acid content and smoke point. This relationship is shown in fig. 6. The first degree curve fitted to the data gave the following equation:

$$Y = 240^\circ \text{ C.} - 11 \sqrt{x}$$

where Y = smoke point in degrees centigrade
and x = free fatty acid content in hundredths of a percent.

TABLE 17. RELATIONSHIP BETWEEN CHEMICAL AND PHYSICAL PROPERTIES OF LARD AND VOLUME OF LARD RENDERED.*

Method of rendering	Average volume	Average FFA content	Average melting point	Average stability	Average red color	Average yellow color
Open kettle	312,583	0.47	36.0	3.3	1.3	5.2
Dry rendering	12,827,000	0.19	35.1	0.9	0.6	2.8
Prime steam	41,316,700	0.30	33.5	4.8	0.7	3.2

*These coefficients are for samples of lard which did not contain antioxidants.

The correlation coefficient was 0.84. The standard error of estimate was 7° C. Thus, one would expect about two-thirds of the observations to fall within the area of ± 7° C. of the line of relationship. This equation is relevant only in the range of the data used in this chart.

The melting point was so poorly correlated with the refractive index and with the iodine number that figures are not presented.

Table 17 gives an indication of the differences in some of the chemical and physical measures that may be associated with volume and method of rendering, etc. The data shown in this table are discussed in connection with costs in the "Results of the Cost Analysis" section (see table 24).

Since the free fatty acid content may reflect the handling and processing history of the fat, these data were examined in relation to the temperature of rendering, the amount of leaf fat and the hours held before rendering.

The correlation coefficients for the relationships between free fatty acid and these variables were as follows:

Measure	Correlation coefficient
Average temperature	— 0.042
Percent leaf fat	— 0.131
Hours held	— 0.034

None of the coefficients is large enough to be of any practical significance. This may be because the free fatty acid content is a function of several interrelated variables (see section on processing history). For example, when the time of rendering was multiplied by the temperature of rendering, the correlation coefficient was 0.53. This coefficient is significant at the 1-percent level.

It also indicates that some of the variability in the chemical coefficients may be directly related to the combinations of fat treatments.

Similar tests were not made for the other chemical and physical relationships; however, it is reasonable to assume that interrrelationships exist between the processing history of the fat and other chemical and physical properties.

The variation in the method of handling the fats by different plants as shown in tables 1 and 2 should be carefully considered before attempting to evaluate the organoleptic, chemical and physical data.

SECTION C. COST ANALYSIS

Cost comparisons between plants and processes may be misleading unless the costs included in a cost item or department are kept in mind. The definitions and explanations of the cost items used in this study follow.

Definitions of Cost Items Used

EQUIPMENT COSTS

Included in equipment costs were costs of all machinery used in the processing of the product including rendering, packaging, refrigeration and transportation within the plants. Equipment used to process the product beyond the product as lard was not included.

It was intended that equipment costs would be obtained for each step in the process, e.g., rendering, cooling, refining, packaging, etc. Such information could have been separated from the data collected, but since labor costs, administrative costs, etc., could not be allocated satisfactorily to steps in the processing, equipment costs were obtained only for the complete production operation.

The equipment costs used in the study were the estimated replacement costs in 1951. A depreciation rate of 5 percent was used to compute the annual charge. The kinds and amounts of equipment used in each of the three processes is discussed in Section A.

LABOR COSTS

Direct labor costs included all labor used in the direct production of the lard and that used in packaging and other operations of the lard department. Joint labor hours were allocated to the lard department by using managers' estimates to obtain the amount of time worked in the lard department. Labor costs involved in keeping records, accounting, payroll, research, supervision, etc., were included in administrative costs.

The values used were the actual labor costs for the direct and joint labor as explained above. Overtime, provisions for retirement, taxes, etc., were included in the labor bill.

This procedure does not make the labor costs of different sized plants comparable since, in general, the smaller the plant, the lower the wage rate.

BUILDING COSTS

The present replacement cost of the building was used as the base for computing building costs. The amount of the building used for lard (measured in cubic feet) as compared with the total building was used to allocate the building cost to the lard department. This building space was estimated by plant managers and not measured directly.

The present replacement cost was used for the building because data on original cost could not be obtained in many cases.

This procedure tends to overstate the building costs of all firms since most of the plants were built or purchased many years ago and the general price level has risen since that time. The costs will be least accurate for those firms which have had the greatest increase in value since they were purchased or built.

ADMINISTRATIVE COSTS

The cost of administrating the lard department was computed by allocating a portion of the total administrative cost to the lard department. Administrative costs were allocated to the lard department on the basis of the pork fat processed as a percentage of the total weight of the beef, hog and lamb slaughter of the plant. The costs used for these items were the actual costs that the plants were paying.

Other costs included under this general heading were taxes (other than those associated with the labor force), insurance, etc. The appropriate parts of costs of maintenance and supplies for the overall plant and for the lard department *per se* also were grouped with these administrative costs. The inclusion of these costs under the heading of administrative costs explains the relatively high total administrative costs shown in the plants studied.

PROCESSING COSTS

The costs of electricity, steam, antioxidants and other direct materials used in the production process were considered as processing costs. Also included in processing costs were the costs of heating, lighting and related costs which are not directly related to production. The cost of the raw product (hog fat) was not included.

The processing costs were determined by several methods. In some plants, costs were already allocated to the lard department. These costs were used with whatever adjustments were needed to make them comparable between plants.

Often the amount of steam, electricity, etc., used was obtained by actually measuring the amount used to produce a given quantity of lard. This was multiplied by the total production to obtain the quantity used in production. Some processing costs are fixed costs and were added to the production costs to obtain a total cost; electricity used for lighting the plant and steam used to heat the plant are examples.

When these cost items were collected on a physical basis and the actual prices paid for the inputs were not collected, the following prices were used to compute the processing costs.

Physical Inputs	*Prices*
Steam	0.680 per 1,000 cu. ft.
Water	0.060 per 100 cu. ft.
Power (electricity)	0.025 per k.w.h.
Insurance	Plant rate
Supplies	Actual cost to plant
Gas	0.400 per 1,000 cu. ft.
Fuel oil	0.075 per gallon

PACKAGING COSTS

The cost of the containers used in lard production varied so much that a separate category of costs was used. The cost of packaging materials such as cartons, liners, rent on drums, etc., was therefore computed separately from other costs.

Since it was impossible to separate equipment costs and labor costs in the packaging operation, these costs were included in the labor and equipment costs. This procedure makes the labor and equipment costs of the plants which packaged large quantities of small packages appear higher than those of plants which sold most of their lard in tank cars or large containers.

The values used for the cost items were the actual costs which the plant paid for their materials.

OTHER COSTS

Some cost items were excluded from the study. These included advertising and selling costs and investment in operating capital and inventory, including the cost of the raw material.

These costs are pertinent to the cost structure of any firm but were not included in the data collected for this study because of time and money limitations. Because these costs are excluded, the total costs shown in this manuscript are somewhat less than the actual total cost of rendering lard in the plants studied.

Capacity

The cost of operating a firm will vary greatly with the capacity at which the firm is operated. The items most likely to be affected by capacity at which the plant is operated are equipment and labor costs. Economies in buying and selling are also experienced as the plant operates more closely to capacity.

The effects on costs of operating at a higher degree of capacity can be easily demonstrated. The annual equipment costs for the average-sized firm using the open kettle process was about $150. These firms operated at a capacity of about 1,000 pounds of lard production per week, which was about 20 percent of capacity. Thus, the annual average equipment cost of producing lard would be almost 0.29 cent per pound ($150 ÷ 52,000). If the plant was operated to capacity, this cost would be $150 ÷ 260,000 or about 0.06 cent per pound of lard produced. This clearly shows that the costs of equipment are a function of the capacity at which the plants operated. Other costs probably also are related to the capacity at which the plants operated. The average capacities of the plants using the different processing methods are shown in table 18.

TABLE 18. OPERATING CAPACITY OF LARD DEPARTMENTS USING DIFFERENT PROCESSING METHODS.

Method of rendering	Relative size	Average annual percentage of capacity of lard department
Open kettle	Very small	10*
	Small	18
	Medium sized	20
	Large	30
Dry rendered		60
Prime steam		50

*Numerical averages.

TABLE 19. AMOUNT OF LARD SOLD IN DIFFERENT SIZE PACKAGES (CLASSIFIED BY METHOD OF PROCESSING).

Size container	Process			
	Steam	Open kettle	Dry rendered	Total
(cartons)	(thousand pounds)	(thousand pounds)	(thousand pounds)	
1	22,045	838	1,632	24,515
2	6,452	167	——	6,619
3	——	——	3,136	3,136
4	14,554	——	——	14,554
5	——	483	——	483
8	909	——	——	909
4 tins	5,150	——	——	5,150
8 "	3,679	——	——	3,679
16 "	640	——	——	640
25 "	1,888	——	——	1,888
37 "	12,541	——	——	12,541
50 "	12,137	517	858	13,512
56 "	39,378	——	——	39,378
57 "	114	——	——	114
36 "	——	——	393	393
120 "	1,620	469	92	2,181
400 "	5,750	377	——	6,127
410 Tierces	4,259	3	974	5,236
Barrels or tank cars	19,615	——	31,035	50,650
Total	150,731	2,854	38,120	191,705

Percent of capacity at which the plants operated may be one of the reasons for the differences in costs which exist.

AVERAGE PACKAGE SIZE

The effects upon production costs of packaging different sizes, types and quantities of lard were discussed previously. The variability in size of packages is shown in table 19. Table 19 also shows the amounts of lard sold in different size containers in 1951 classified by process. The largest amount of lard was sold in tank cars — 50,650,000 pounds. The 56-pound tins ranked second with 39,378,000 pounds, while 1-pound packages ranked third with 24,515,000 pounds.

The size of the package is a rough indicator of the final use of the product, but precise information regarding the final use of lard merchandised in different size containers was not available. It is generally assumed that 56-pound tins are for export purposes. In general, it may be assumed that the smaller packages are used in the household and that the middle-sized containers are used in institutions, bakeries, etc.

Results of the Cost Analysis

The costs of producing lard were computed by cost items for 19 plants (for this part of the analysis a firm which produced lard by two methods was considered as two plants).

Since this study was a case study designed to show the variability in cost structure and to investigate the reasons for these cost differences, cost variations and reasons for differences in costs of the different methods of processing are shown separately.

OPEN KETTLE

As mentioned in Section A, plants producing lard by the open kettle process were separated into four categories, based on their annual volume of production in 1951. The weighted average costs per 1,000 pounds of production for each of the cost items and capacity at which the plants operated for each of the different size categories are presented in table 20.

Labor cost is the major cost item, accounting for 58 percent of the total cost (excluding packaging costs) for the very small firms and 62 percent for the small firms. Labor costs, as a percentage of total cost, declined to 37 percent for the large plants. The difference in labor costs accounted for 86 percent of the total difference in costs of the various sized plants (excluding packaging costs). This reduction in labor costs existed even though the wage rate was increasing with increased volumes of production. The efficiency in the use of labor is shown by the hours of labor required to produce 1,000 pounds of lard. The hours required in the very small plant were 14.6 while 7.5 hours were needed for the medium-sized plant. Only 3.6 hours were required to produce this much lard in the large plants.

This increase in labor efficiency may not all be because of volume of production. Part of it is probably due to the percent of capacity at which the plants operated. The very small plants operated at about 10 percent of capacity while the large plants operated at about 55 percent of capacity on the average.

The percent of capacity at which the plants operated affected the equipment costs. In general, the small plants and the very small plants had about the same equipment; thus, when the percent of capacity was increased from 10 to 18 percent, the average equipment cost dropped to $3.24 per 1,000 pounds of lard produced in the very small plants and to $1.93 in the small plants. The medium-sized plants had more and larger equipment so that, even with a higher percentage of capacity use, their equipment cost exceeded that of the smaller plant. The large plants had much more equipment than any of the other groups, but their increased volume of production and higher percentage of capacity kept their equipment costs down to $2.77 per 1,000 pounds of lard produced.

The large and very small plants had the highest building costs. While the buildings for the small plants were less expensive, the overall ratio of building costs to volume of lard produced per cubic foot of space was greater for these plants than for the larger plants. The large plants had high building costs because of the type of construction. Also space for research, quality control work, etc., in the lard department was allocated to the lard department. The additional cost of these items was not offset by the increase in volume of production or percent of capacity at which the plants operated.

The large plant had a decided cost advantage when processing costs were considered — despite the fact that these plants did considerably more processing. This advantage is obtained because less electricity, steam, water, etc., is needed per pound of lard rendered as the volume of production increases. Also, the more of these units used, the less they cost the plant per unit.

Total production costs, excluding packaging cost, decreased as the average volume increased. Associated with this volume increase, however, was an increase in the capacity at which the plants operated.

The total production cost declined from $30.51 per 1,000 pounds of lard produced in the very small plants to $29.49 for the small plants. It declined from $23.86 for the medium-size plants to $17.32 for the large plants. Most of the difference in total

TABLE 20. COSTS AND OTHER CHARACTERISTICS OF 12 PLANTS PRODUCING LARD BY THE OPEN KETTLE METHOD, 1951.

Size category†	Annual production	Cost items*: Labor	Equipment	Building	Administrative	Processing	Total production cost	Packaging	Hours labor‡	Per cent capacity§	Wage rate
	(thousand pounds)	($)	($)	($)	($)	($)	($)	($)		(%)	($)
Very small	23	17.81	3.24	2.14	2.96	4.36	30.51	8.99	14.6	10	1.22
Small	64	18.37	1.93	1.38	4.17	3.64	29.49	9.30	13.4	18	1.37
Medium	124	11.52	3.44	1.35	3.03	4.52	23.86	8.80	7.5	29	1.53
Large	1,073	6.44	2.77	2.17	3.26	2.68	17.32	10.66	3.6	55	1.79
Average	313	7.93	2.82	2.04	3.27	2.93	18.99	10.38	4.8	28	2.65

* All costs are weighted average cost per 1,000 pounds of production.

† Three plants are included in each category.

‡ Hours of labor required to produce 1,000 pounds of lard (weighted average).

§ Numerical averages.

costs between the small, medium and large plants can be attributed to a decrease in labor costs. The major difference in costs of producing lard between the very small plant and the small plant is due to the increase in capacity or decrease in equipment cost.

DRY RENDERING

Although it would have been desirable to have studied several different sizes of plants operating at different levels of capacity, it was impossible to do so because plants of different sizes and operating capacities did not exist in the Midwest. Also, financial and time limitation precluded studying many plants. Three plants were selected for study. Costs and related data for 1951 are shown in table 21.

The annual production of the largest plant using the dry rendering method of producing lard was several times as great as the annual production of the smallest firm. This large firm also operated at an extremely high percentage of capacity.

Although this plant paid a higher wage rate and more overtime, its labor cost was much smaller than the labor costs for the other two smaller plants. This is probably because of the volume and percentage of capacity at which the plant operated.

The average volume of production of these plants was 12,827,000 pounds. Labor costs made up about 18 percent of the total cost of rendering lard (packaging cost not included in total cost). Equipment costs made up about 15 percent of the total cost. The plants operated, on the average, at about 60 percent of capacity.

Since one firm had extremely large production and low per-pound production costs relative to the other two plants, these averages are heavily weighted by the figures from this large plant.

PRIME STEAM

Four plants were used to examine the costs of producing lard by the prime steam processing method. Cost data and other characteristics of this method are shown in table 22.

The labor cost constituted about 29 percent of the total cost of rendering lard (packaging cost omitted). One thousand pounds of lard were produced in these plants with just over 2 hours of labor. This efficiency in using labor could be obtained only by using a large quantity of equipment per man employed. The cost could probably be reduced further by increasing the percentage of capacity at which the plants operate.

TABLE 21. COSTS AND OTHER CHARACTERISTICS OF THREE PLANTS PRODUCING LARD BY THE DRY RENDERING PROCESS, 1951.

Annual production (weighted average pounds)	12,827,000
Labor cost ($ per 1,000 pounds)*	2.97
Equipment cost ($ per 1,000 pounds)	2.42
Building cost ($ per 1,000 pounds)	0.50
Administrative costs ($ per 1,000 pounds)	1.03
Processing costs ($ per 1,000 pounds)	2.36
Total production costs (sum of above)	9.28
Packaging costs ($ per 1,000 pounds)	2.90
Total production costs (including packaging costs)	12.18
Hours of labor required to produce 1,000 pounds of lard	1.51
Percent of capacity (numerical average)	0.60
Wage rate ($ per hour, including retirement, taxes, overtime, etc.)	1.97

* Cost data are all weighted averages.

TABLE 22. COSTS AND OTHER CHARACTERISTICS OF FOUR PLANTS PRODUCING BY THE PRIME STEAM METHOD.

Annual production (weighted average pounds)	41,316,700
Labor cost ($ per 1,000 pounds)*	3.98
Equipment cost ($ per 1,000 pounds)	1.94
Building cost ($ per 1,000 pounds)	0.42
Administrative costs ($ per 1,000 pounds)	4.83
Processing costs ($ per 1,000 pounds)	2.46
Total production costs (sum of above)	13.63
Packaging costs ($ per 1,000 pounds)	11.25
Total production costs ($ per 1,000 pounds)	24.88
Hours of labor required to produce 1,000 pounds of lard	2.08
Percent of capacity (numerical average)	0.50
Wage rate ($ per hour, including retirement, overtime, taxes, etc.)	1.91

* Cost data are all weighted averages.

The administrative costs were high relative to other costs. This is probably because of the fact that these plants were large enough to allocate a full-time manager for the lard department or to have a large portion of the salary of a department manager allocated to the lard department. Also, labor costs associated with quality control work, research relating to lard production, etc., are included in administrative costs.

One plant included in this group was extremely small relative to the other firms. This small firm operated at a lower percentage of capacity and had higher per-pound costs for labor and equipment than the larger firms.

The largest plant had an annual production nearly twice as great as the next largest plant. This largest plant had lower per-pound labor and equipment costs than the average of the other three plants.

Comparison of Costs, Volumes and Methods of Rendering Lard

The volume of lard produced, percent of capacity and like factors should also be considered in making cost comparisons of the different methods of rendering lard. Table 23 shows the average weighted costs of producing lard by the three different methods, volumes of production and average numerical percentage of capacity at which the plants operated.

On the average, the plants using the open kettle process were much smaller and operated at a much lower percentage of capacity than the other two processes. Associated with this small volume and percentage of capacity is higher total production costs per 1,000 pounds of lard produced. The cost of every cost item except administrative cost was larger for the open kettle process than for the other methods of rendering lard.

On the average, the plants using the prime steam method produced more than three times the output of the dry rendering plants and many

TABLE 23. COSTS AND OTHER CHARACTERISTICS OF THREE METHODS OF PRODUCING LARD, 1951.

Characteristics	Dry rendered	Prime steam	Open kettle
Annual production(weighted average thousand pounds)	12,827	41,317	313
Labor cost ($ per 1,000 pounds)*	2.97	3.98	7.93
Equipment cost ($ per 1,000 pounds)	2.42	1.94	2.82
Building cost ($ per 1,000 pounds)	0.50	0.42	2.04
Administrative costs ($ per 1,000 pounds)	1.03	4.83	3.27
Processing costs ($ per 1,000 pounds)	2.36	2.46	2.93
Average production costs (sum of above)	9.28	13.63	18.99
Packaging costs ($ per 1,000 pounds)	2.90	11.25	10.38
Total costs (including packaging costs)	12.18	24.88	29.37
Hours of labor required to produce 1,000 pounds of lard	1.51	2.08	4.80
Percent of capacity (numerical average)	0.60	0.50	0.28
Wage rate ($ per hour, including retirement, taxes, overtime, etc.)	1.97	1.91	1.65

* Cost data are all weighted averages.

times the output of the open kettle plants. However, the prime steam plants did not operate, on the average, at as high a percentage of capacity as the dry rendering plants.

Labor costs for the open kettle process were almost twice that for the prime steam process and more than double that for the dry rendering process, despite the fact that costs per hour of labor were higher for the prime steam and dry rendering methods.

The dry rendering method was the least expensive method. This was partially because one large dry rendering plant operated at an extremely high percentage of capacity, thus making very efficient use of labor, buildings and equipment.

This study was not designed to examine cause and effect of these cost variations. The preceding section merely sets out the differences in costs and gives some of the reasons why some of these cost variations exist within and between processes. But remember that these variations in costs are associated wth many other variations, such as volume, percent of capacity, amount of processing, etc.

Relationship Between Costs, Volumes, Rendering Methods and Quality

There were no indications in this study that cost was related to quality or that any additional costs of any magnitude were incurred in producing a good quality product over a product of lower quality. This conclusion is based on a comparison of the quality of lard and the cost of producing lard within processes. In each of the three processes, the individual plant with the best quality product as measured by the chemical and organoleptic tests also had the lowest average cost. The low cost and the quality characteristics of the product in this case probably are due partially to management of the plant. The managers doing the best job would be expected to operate plants which had the lowest cost and highest quality product, other things being equal.

The relationship between cost and quality are shown in table 24. This table shows that costs are inversely related to the quality attributes measured. Even though more processing was done by the prime steam and dry rendering plants, their costs were lower than for the open kettle plants. The relationships between volumes, methods of rendering, etc., must be kept in mind when comparing cost and quality relationships.

It is usually assumed that additional steps in the processing will improve the quality of the lard. Obviously, for a given plant with a given process in operation, the addition of another processing step would incur a cost. Since it was impossible to obtain accurate production costs on a step by step basis, information on the magnitude of these increased costs as new processing steps are added is not available.

Relationship Between "Quality" and Prices Received

Processors will not be enthusiastic about improving quality unless the resulting product can be sold more profitably. An effort was made to determine if lards possessing more desirable characteristics were being sold for a premium.

The price data obtained from the plants were the annual prices they received for their lard. Some plant managers refused to give price data, and others gave only total sales value and total pounds of lard sold. Since sales value depends on the size of the container, it was impractical to attempt to compare prices received unless they could be compared on an equal basis — such as 1-pound cartons or tank cars.

There was little or no relationship between the

TABLE 24. RELATIONSHIP BETWEEN CHEMICAL AND PHYSICAL PROPERTIES OF LARD, VOLUME OF LARD RENDERED AND COSTS.*

Method of rendering	Average volume (thousand pounds)	Average FFA content†	Average melting point‡	Average stability (AOM)	Average red color§	Average yellow color§	Average cost**
Open kettle	313	0.468	35.95	3.32	1.27	5.2	$18.99
Dry rendering	12,827	0.194	35.12	0.86	0.64	2.8	9.28
Prime steam	41,317	0.300	33.48	4.82	0.67	3.2	13.63

* These data (except costs) are for samples of lard which did not contain antioxidants.
† Percent oleic.
‡ Degrees centigrade.
§ Lovibond.
** Cost per 1,000 pounds of lard produced. Cost does not include packaging cost.

quality of the lard produced and the price received for the lard in the plants studied. Some of the plants which were doing a relatively poor job of processing lard were doing an excellent job of merchandising. Other plants were doing a good job of quality control but were not doing so well in marketing the product. Also, several small plants, with a limited production of lard, were selling directly to consumers at retail prices while large plants were not able to do so.

Another factor affecting the average yearly price received is the seasonal variation in prices. The plants selling at the seasonal price peaks may obtain more, even if their lard is discounted, than the plant that sells its lard at lower seasonal prices.

SECTION D. DISCUSSION AND GENERAL OBSERVATIONS

The results obtained in this study do not provide a firm basis for evaluating the influence of processing methods on the characteristics of the lard produced. The lard produced in the plants studied was handled in so many different ways prior to and during rendering that the data obtained are not directly comparable. Therefore, these data must be largely related to the specific practices and conditions which attended the production of each sample of lard.

An investigation of the effect of different processing techniques on the quality of lard should be based on standardized processing procedures for handling and rendering the fat.

A more complete study would involve several additional factors, namely:

(1) crystal formation,

(2) proportion of crystalline to liquid fat (influences plasticity range),

(3) stability in baked or fried foods,

(4) development of color or odor in fat added to foods which are heated during preparation and

(5) the ultimate use of the lard.

The assessment of the relative importance of factors which may contribute to the quality of lard is limited in this study to the physical, chemical and organoleptic data collected.

It is well known that lard intended for pie making should have a wide plastic range, whereas this consideration is less important in the preparation of many other foods.

A high smoking point is desirable for a fat used for deep frying; however, for certain other uses (cake mixes), an important characteristic of the fat is dispersibility. This property is enhanced by adding emulsifying agents (monoglycerides and diglycerides), but such agents lower the smoke point of the fat appreciably. In this instance, the two properties are antagonistic.

The stability of cooking fats is greatly increased by adding antioxidants. The choice of antioxidant depends upon several considerations, all of which are outside the scope of this investigation.

No single antioxidant is completely satisfactory, e.g., gum guaic appears to give good shelf life but AOM may not be good. Some antioxidants give good AOM values but do not have good "carry through." A few antioxidants produce, under certain conditions, discoloration of the fat. NDGA (nordihydroguariaretic acid) and propyl gallate, for example, may have this disadvantage. In other cases, certain antioxidants added to fat may produce undesirable odors when heated.

The appearance and color of lard can be influenced considerably by the amount of air incorporated into the fat at the time of filling the container.

The final evaluation of a fat for cooking should not be based entirely on chemical and physical tests since the quality characteristics desired in cooking fats depend on the ultimate use.

On the other hand, the physical, chemical and organoleptic tests have their place in quality evaluation of any fat. Certainly, if the smoking point is high, the fat can be used for a longer period in frying before it begins to smoke, or it may not smoke at all while being used. The advantage of a high smoke point is obvious in this instance.

Lard with a low melting point or high iodine number is not desirable for several reasons. If kept in a warm room, it may become oily and unattractive. The larger amounts of unsaturated acids in such fats make them more susceptible to oxidation if antioxidants are not added. However, soft lards may possess greater shortening value.

The stability tests (shelf life and AOM) have some merit since they may be used with reservation to predict the approximate storage life of the lard. Free fatty acid and peroxide content, if high, indicate abuse of the fat before, during or after processing. Several factors contribute to the high free fatty acid and peroxide contents — holding the raw fat too long or at too high a temperature before rendering, excessive or prolonged heating during rendering and poor storage conditions after rendering. Improper cleaning of equipment used to render the fat is another contributing factor. Metal contamination and excessive contact with air, especially while the fat is hot, are additional factors whch will influence the peroxide content of a fat.

Brown or yellow discoloration in lard is an indication of scorching from prolonged heating at high temperatures during rendering. If cracklings are scorched (open kettle or dry rendering), the lard pressed from them will be dark and will have a more pronounced flavor.

Organoleptic testing will reveal odors and flavors if present in appreciable amounts and, therefore, are useful tests. Visual examination provides useful information about the color and texture of the fat.

Previous research has shown that there is a great deal of variation in the properties of lard produced from the fat of different hogs. Hogs fed a ration with a high percentage of soybeans will have a soft, oily fat. Hogs which gain slowly may have a different type of fat than hogs which grow very rapidly.

A small plant might easily obtain a group of hogs that had some of the above or similar characteristics. If fat from a large number of hogs is rendered, the influences of feeding, managing and genetic makeup of hogs are less important than they would be for fat rendered from a small number of similar hogs. This may partially explain the differences in the variability of lard from large plants when contrasted with lard produced by small plants.

Another hypothesis might be that the small plants are less quality conscious or are not large enough to have research laboratories and other services to aid them in quality control.

The absence of certain relationships in the data may be very important. It was found that the free fatty acid content, color, flavor and shelf life were not consistently related to stability (AOM) or with each other. The variation found in these relationships indicates that they are complex.

These investigations considered in aggregate clearly show that the lard produced by commercial processing methods possesses variable characteristics. The data show that the methods of handling fat prior to, during and after rendering is not consistent within or between plants. The variability in the various organoleptic, chemical and physical properties of the lards produced, however, could not be associated with any single treatment except that shelf life or stability of lard could be increased by adding antioxidants.

Some evidence was obtained that the dry rendering method produced lard with better aggregate quality characteristics. The open kettle rendered lard was the most variable insofar as these considerations are concerned.

Some of the variability in the characteristics of the lard was associated with the time of the year it was produced. No explanation for this association is apparent in the data.

The final evaluation of a product rests with the consumer. Whether or not consumers will accept a given food item will depend on several factors. Many of these factors are subjective, making it extremely difficult to predict consumer reaction. The object of this study was to determine differences rather than to examine consumer preferences. In the absence of a consumer rating for each sample, it is impossible to relate the factors tested with consumer preferences.

When comparing the costs of processing lard, the cost estimates which have been made are not exactly comparable. Each of the plants and methods has different kinds and amounts of processing done to the lard. On the average for the plants studied, the least amount of processing was done to the lard in the open kettle method of rendering and the most was done in the dry rendering method.

Any cost-volume relationships may be because of the volume of production or the method of rendering, percentage of capacity at which the firm operated or other associated factors. The plants with a small volume of operation used the open kettle method of rendering lard. The rendering plants using the dry method were the medium-sized plants, and the large plants used the prime steam method. Thus, the higher average cost for the open kettle method of rendering lard may be because of the volume of operation rather than because it is a more expensive processing method.

The reason why the dry rendering plants had the lowest average cost may be because they operated more closely to capacity throughout the year than did the larger prime steam plants. The excess capacity which the larger slaughter plants maintain to take care of changing supply may increase their costs above the costs of the medium-sized firms which operated more closely to capacity.

Certainly the percent of capacity at which the plants operated had some effect on the average cost of producing lard. The small plants (open kettle) operated at the lowest percent of capacity; the large plants (prime steam) operated at the next to lowest percent of capacity; and the medium-sized dry rendering plants operated at the highest percentage of capacity.

Since this was a case study to determine the quality characteristics, costs and some of the reasons related to quality and cost variations, it was impossible to statistically measure the effects of volume and percent of capacity on costs to that point that causality might be logically assumed. The study does, however, suggest that these conditions might exist and points out the need for a comprehensive statistical study to measure the degree of relationship between volume, costs and percent of capacity at which the plant is operated. This need requires a sample design which would be stratified on the basis of volume, percent of capacity, type of process, volume of production, etc. This would permit the effects of each variable to be separated from other variables by a multi-variate analysis.

Management is an important factor in the cost operations of any firm. The failure to evaluate management was not an oversight in the study but was not attempted because of the absence of known techniques to measure efficiency of management.

Certain aspects of conducting this study might be of interest to others who plan on doing a study of cost structures, cost-volume relationships and the like.

There is little standardization within the industry in the way records are kept or the methods used to allocate costs between departments. Furthermore, cost accounting methods may differ in allocating costs to different departments within a single packing plant.

Future researchers would do well to have the cooperating plants begin keeping the specific records needed for analysis at least a year before the date that the analysis will be made. This will reduce some of the problems of cost allocations and will save the researchers and plant personnel many hours of labor in trying to collect comparable records from different plants.