Meat - Prices

PRICE PREMIUMS FOR QUALITY BEEF STEAKS

A Supermarket Experiment

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INTRODUCTION

The introduction on a national level of a new or improved branded food product by a market orientated company implies that many conditions have been satisfied. A marketing director conscious of the need for a favourable market share will have satisfied himself by a variety of preliminary tests that the quality characteristics of his product are at least as acceptable to consumers as competitors' products. Psychological testing may have been used, perhaps to contribute towards the formulation of advertising strategy or even to select a brand name. Test marketing may have been undertaken, perhaps lasting for several months, to enable appraisal of alternative marketing strategies and to assess sales potential. It will have been in the light of the results from these that the national marketing decisions will have been made. Even so, it is often difficult to isolate any single factor as being the most influential determinant of the overall plan or the most important factor influencing consumers' decisions to buy (or not to purchase).

Certainly, however, the price at which the product is sold is only one of many factors contributing to overall success or failure. Sometimes techniques are used in which potential customers are asked to estimate the price at which they would be prepared to buy the product, though most marketing managers would be sceptical of the face value of such results. Often price is assessed in relation to alternative financial plans which embody sales forecasts and cost estimates. In any case, the actual price can be disguised during execution of the marketing plan by varying promotional tactics through time, for example by offering gifts.

In meat retailing the forms taken by competition are rather different. Evidence suggests that for a variety of reasons over three-quarters of all housewives regularly buy their meat from the same shop[1]. One is led to suppose that most customers do not shop around for meat. Within the butcher's shop, however, there is ample evidence, supported by statistical analyses of national data, to show that consumers switch from one type of meat to another in response to changes in the relative prices

(1) G. H. Brayshaw and R. J. Perkins, *The Competitive Advantages of Alternative Methods of Meat Retailing*, Department of Agricultural Marketing, University of Newcastle, Report No. 5, 1966.

of these types[2]. Similarly, from supermarket experiments, it is well known that sales per square foot depend partly on the internal layout of the store, and that the success of any single product depends upon its location and display in relation to competitive brands[3].

Thus, although the scale of decision making of the retailer may not be the same as for the marketing manager of a national brand, the same complex inter-relationships between many variables most certainly exist. In this report, however, we have isolated for analysis two of the more important variables, price and quality of meat, which are amenable to continuous assessment by the butcher.

Some aspects of consumer preferences for quality are already known. Summarising the results of earlier consumer tests, it was found that about 85 per cent of consumers require steaks with less than 30 per cent of the surface area comprising fat[4]. That leanness is the most important quality factor visible to housewives in the butcher's shop has been shown by another survey[5], and in the same analysis the majority of butchers rated tenderness as the second most important characteristic of meat demanded by customers. Indeed, in one large-scale consumer test, tenderness was the only quality characteristic which had a measurable influence on the overall acceptability of meat when actually eaten, and the conclusion was reached that over three-quarters of consumers are at least 'moderately' satisfied with steak so long as its shear resistance, measured by the Warner Bratzler instrument, is no more than about 22 lb.[6].

Both of these quality characteristics—leanness and tenderness—can be and are influenced by the practices adopted by butchers, especially by trimming to varying degrees and by hanging for longer or shorter periods. To some extent, also, variations can be achieved by buying leaner or fattier carcasses or by purchasing meat from younger or older beasts. However, whilst one can be reasonably confident in listing the main quality factors ideally required by the majority of the market, one needs very much to know the extent to which consumers are prepared to pay for these attributes before rational pricing, purchasing and production policies can be adopted.

In the experiment reported here such an attempt has been made, though on a very small scale. The experiment was devised solely to assess the price premiums, if any, which might be expected for quality steaks from beef animals. At the same time it was hoped that the information would provide some guidance to the worthwhileness and disadvantages of alternative trimming, purchasing, pricing and production policies.

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(2) For example, the Annual Reports of the National Food Survey Committee, *Domestic Food Consumption and Expenditure,* H.M.S.O.
(3) *The Colonial Study,* Progressive Grocer, 1963-64.
(4) G. H. Brayshaw, E. M. Carpenter and R. J. Perkins, *Consumer preferences for Beef Steaks,* Department of Agricultural Marketing, University of Newcastle, Report No. 2, 1967.
(5) G. H. Brayshaw, E. M. Carpenter and R. A. Phillips, *Butchers and their Customers,* Department of Agricultural Marketing, University of Newcastle, Report No. 1, 1965.
(6) G. H. Brayshaw, E. M. Carpenter and R. J. Perkins, *op. cit.*

CHAPTER I

EXPERIMENTAL METHOD

Sales of experimental beef steaks were undertaken in a large North London supermarket during the seven-week period from October 1st to December 8th, 1966. Even though no data can be revealed about the aggregate turnover of the store, or of its total meat sales, those of the experimental beef steaks alone averaged more than £85 per week during the test period. This gives an indication of the store's total butchery business.

Steaks of two basic descriptions were made available, strictly on a self-service basis. The display spaces allocated to these were always kept equally full[7], reserve stock was always on hand, and old packs were removed at the discretion of the butchery manager for disposal. The first category of steaks, from topsides, were labelled as frying steaks; and the second, from prime sirloin, were described as porterhouse steaks.

Within each classification steaks were divided into two groups. The frying steaks were designated on the cabinet facings as FRYING STEAK or BEST FRYING STEAK according to their estimated degree of tenderness assumed to be influenced by the length of hanging period, but otherwise the two types were as homogeneous as possible. Likewise, the porterhouse steaks were divided into two groups, described in the store as PORTERHOUSE STEAK and BEST PORTERHOUSE STEAK, according to the estimated degree of leanness of the steaks. The four groups were displayed separately, with two facings for each group, the price per pound was clearly marked on the facings, and each pre-pack was also identified in the conventional way.

Instore Display and Pricing

Adjacent to the experimental packs the layout of the meat display was as follows in the order of the main traffic flow within the store:

Quick Frying Steak	(4 facings)
**FRYING STEAK*	(2 ,,)
**BEST FRYING STEAK*	(2 ,,)
Pork Chops (chump and loin)	(1 ,,)
Pork Rashers	(2 ,,)
**PORTERHOUSE STEAK*	(2 ,,)
**BEST PORTERHOUSE STEAK*	(2 ,,)
Topside of Beef (joints)	(4 ,,)

(**indicates experimental meat*)

[7] The steaks were on offer from Tuesday to Saturday inclusive each week. In the following analysis a week is defined as starting on a Friday and finishing on Thursday.

During the whole of the seven-week period the only frying steaks and porterhouse steaks on offer in the store were the experimental packs, although the store did continue to sell quick frying steaks, fillet steak and rump steak as well as other potentially competitive cuts.

In general, however, the prices charged for all of the likely competitive meats remained fairly static during the period in which the prices of the experimental steaks were varied. Furthermore, the maximum prices of the possibly competitive cuts occurred only at the beginning of the experimental period, and the prices shown

TABLE 1. **Price Range of Some Competitive Cuts during the Experimental Period**

Cut	Maximum Price (d/lb)	Minimum Price (d/lb)	Maximum Price as % of Minimum Price
BEEF:			
Rump Steak	132	120	110
Fillet Steak	150	150	100
Quick Frying Steak	96	96	100
Sirloin Joints (bone out)	82	78	105
Steak with Kidney	56	52	108
Silverside Joints	76	66	115
Topside Joints	80	70	114
VEAL:			
Escallopes	96	96	100
Leg Fillet	52	52	100
Chump Chops	54	54	100
PORK:			
Chump Chops	72	72	100
Loin Chops	70	70	100
Leg Fillet	72	70	103
Pork Steaks	90	90	100
ENGLISH LAMB:			
Chump Chops	72	72	100
Loin Chops	68	64	106
Leg (middle cut)	66	66	100
OFFAL:			
English Lamb Liver	68	68	100
English Lamb Kidney	62	62	100

as minimum prices in Table 1 prevailed for most of the seven-week period. The prices of other cuts, not shown in Table 1, were in all cases substantially lower than those charged for the experimental steaks; for example, mince, braising and stewing steak, ribs and brisket. For the most part the prices of these were held constant throughout the period in question.

No systematic check was kept of prices charged for comparable cuts in other butchers' shops in the same neighbourhood, but the evidence provided by wholesale prices during the same period strongly suggests that no dramatic changes in prices were occurring at that time. Indeed, the national seamen's strike in the

summer of 1966, which had incidentally caused the experiment to be postponed until late October, had as its aftermath a strong governmental appeal to butchers, and others, to keep prices steady.

TABLE 2. **London Smithfield Average Minimum and Maximum Wholesale Prices**

(pence/lb.)

Date	Scotch Killed Sides	English Long Sides
20.10.66	24 —30½	21½—26
27.10.66	25 —30½	21½—25½
3.11.66	21½—30	21½—25
10.11.66	22 —30	21 —24½
17.11.66	22 —29½	21 —24½
24.11.66	23 —30	21 —25
1.12.66	22 —30	20½—24½
8.12.66	23 —31	21 —26

Within this environment, the intention during the shop test was to hold the prices of the ordinary grades of frying steak and porterhouse steak at the commercial levels which the supermarket would have normally charged. For the best grades of the two types a premium of sixpence per pound was charged during the first three weeks of the experiment, and thereafter the premium was increased steadily at weekly intervals until the end of the test period, as shown in Table 3.

TABLE 3. **Prices Charged for Experimental Steaks**

(pence/lb.)

Week	Frying Steak	Best Frying Steak	Porterhouse Steak	Best Porterhouse Steak
1	102	108	138	144
2	102	108	138	144
3	102	108	138	144
4	102	120	135	153
5	102	132	132	162
6	102	144	132	174
7	102	156	132	186

PROCUREMENT AND MEASUREMENT OF EXPERIMENTAL MEAT

(*a*) *Frying and Best Frying Steaks*

These were cut from topsides purchased from a single abattoir throughout the period. They were from Hereford x Friesian steers of Irish origin. fattened on the Lincolnshire marshes and coming to slaughter at approximately three years of age. These were slaughtered on the same day each week, and the labelled topbits[8] were delivered to the supermarket for hanging, cutting and pre-packaging. At the super-

[8] Consisting of topside, silverside, top rump, aitchbone, leg of beef, cod-fat and flank.

market the two topbits from each carcass were allocated at random to a short or long hanging treatment, labelled and stored in the chill-room. For sales on Fridays and Saturdays the steaks described as 'frying steak' were derived from tops hung for 3–4 days whilst those to be sold as 'best frying steak' had hung for 10–11 days. For these two days, preparation and pre-packaging was commenced on the Thursday. From Tuesday onwards an appropriate number of topbits were prepared for sale on Tuesday, Wednesday and Thursday after hanging for 7–9 days in the case of 'frying steak' or 14–16 days in the case of 'best frying steak'. Throughout the test period only the topsides were used in the experiment, the remainder of the topbits being disposed of elsewhere by the supermarket.

Each day a random sample of steaks was retained for measurement after preparation and handling in the same way as the other steaks put on display. These sample steaks were cooked and sheared with the Warner Bratzler instrument at the end of the day to provide a check on the tenderness of the steaks at the time of sale with the results shown in Table 4.

TABLE 4. **Mean Weekly Shear Values (lb.)***

Week	Frying Steak	Best Frying Steak
1	22.11	18.49
2	18.52	13.94
3	16.45	13.62
4	17.96	14.96
5	14.32	13.90
6	15.28	15.35
7	14.26	13.55

(*Shear values decrease as steak becomes more tender).

(*b*) *Porterhouse and Best Porterhouse Steak*

Both grades of porterhouse steaks were prepared from prime sirloin joints made available by the supermarket. These were boned out and cut into two halves, the wingend and the undercut without fillet. One half was cut into steaks without trimming for sale in pre-packs as 'porterhouse steak' whilst the other half was cut into steaks, severely trimmed before prepacking, and described as 'best porterhouse steak'. The wingend and undercut was trimmed or left untrimmed alternatively on consecutive joints in the same manner and in all cases the total trim weight was calculated before disposal.

Each day random samples of trimmed and untrimmed steaks were photographed under standard conditions, and the photographs were used to measure the area of visible fat and lean of the steaks on offer. Additionally, a small sample of the photographed steaks was retained for dissection, in order to weigh the proportions of fat and lean meat.

TABLE 5. **Fattiness of Experimental Sirloin Steaks**

(Fat Area as per cent of total face area)**

Week	Porterhouse Steak	Best Porterhouse Steak
1	29.83	22.87
2	32.46	21.47
3	31.02	19.76
4	29.99	13.85
5	30.56	14.52
6	29.28	12.32
7	32.03	12.95

(** As measured from photographs by planimeter)

(c) *Assessment of Measurements*

During every week, and in fact on every sales day, the best porterhouse was significantly leaner than the ordinary grade of porterhouse. In view of earlier evidence that consumers are able to differentiate to fine limits between the degrees of leanness of sirloin steaks possessing different proportions of fat and lean[9], one can be confident that the two grades on offer in this experiment also appeared recognisably different to prospective customers.

For the test sales of frying and best frying steak, however, one is much less confident that the two grades were always significantly different with respect to degree of tenderness. On five out of the thirty-five sales days the mean shear value of the grade labelled as best was in fact marginally higher (therefore, tougher) than for the lower priced frying steaks. Using the weekly average shear values Table 4 indicates that in one week the best grade was also slightly, though not significantly, tougher than the ordinary grade of frying steak. Furthermore, at no time, in spite of using topsides from three-year old beasts hung for a short period of time, was it possible to secure tough meat. With the exception of the first week all of the frying steaks sold were substantially more tender than was earlier reckoned to be necessary to give at least moderate eating satisfaction to three-quarters of consumers.

During the seven-week test it was not always possible to ensure that the topsides would become more tender with hanging in a consistent way, as had been suggested by pre-experimental pilot tests using a sample of 36 topbits. In the pilot tests topbits had been allocated into one of two groups on the basis of the mean shear value of the rump muscle, *Gluteus Medius*, before hanging. After one day of hanging, cores were sheared from a defined muscle from each of nine carcasses and the same procedure was adopted after the remaining topbits had hung for five, ten and fifteen days, with the results shown in Table 6. During the period of experimental sales

[9] G. H. Brayshaw, E. M. Carpenter and R. J. Perkins, *op. cit.*

TABLE 6. **Pilot Tests of Effects of Hanging on Mean Shear Value of a Topside Muscle (lb.)*****

Days Hung	Group 1	Group 2
1	22.04 (±1.20)	21.08 (±1.10)
5	20.70 (±0.96)	19.47 (±1.18)
10	16.11 (±1.18)	18.02 (±1.35)
15	14.86 (±1.14)	14.63 (±1.03)

(*** As measured by Warner Bratzler instrument. The figures in parentheses are standard errors)

these results were not consistently replicated. Whilst tough meat could certainly have been procured for sale at the lower price, the experimenters had undertaken not to damage the store's reputation by offering for sale meat which was inferior to that normally sold in the store under the label of 'frying steak'.

CHAPTER II

PRICE PREMIUMS AND SALES

Each day during the experimental period detailed records were made of the number of packs sold and the weight of meat sold of each of the four groups of steak. The weekly summaries are shown in Table 7, and in Figs. 1 and 2, and form the basis for the analysis below. The detailed daily quantities sold are tabulated in Appendix A.

TABLE 7. **Weekly Sales Summaries***

	Av. for weeks 1—3		Week 4		Week 5		Week 6		Week 7	
	Packs	Ozs.	Packs	Ozs.	Packs	Ozs.	Packs	Ozs.	Packs	Ozs.
Frying Steak	162	814	148	847	165	928	124	876	139	974
Best Frying Steak	140	694	118	642	72	414	51	321	40	260
Porterhouse Steak	98	480	103	539	128	636	148	788	120	700
Best Porterhouse Steak	174	637	139	711	144	661	125	540	94	447

(* Weight sold per week is rounded to the nearest ounce)

During the first three weeks, when all prices were held constant, sales of each class of steak fluctuated but it did not appear that the level of sales either increased or decreased consistently through this period (Table 8). During the subsequent four weeks, however, when the ratio of the price of the best grade to the price of the ordinary grade was increased at weekly intervals, clear sales trends did manifest themselves as shown in Table 7. It, therefore, seems reasonable to postulate that sales of any grade are largely dependent upon its price in relation to the prices of competitive cuts, and not merely dependent upon the passing of time.

TABLE 8. **Weekly Sales in the First Three Weeks (ounces)**

	Week 1	Week 2	Week 3
Frying Steak	912	721	809
Best Frying Steak	684	683	716
Porterhouse Steak	494	452	494
Best Porterhouse Steak	500	716	696

Using the sales data from Table 7 and the price levels given in Table 3, the weekly sales of each grade are plotted against the price of that grade in relation to the price of the grade's nearest competitor in Figures 3 to 6. Thus, as the price of best frying steak rises relative to the price of ordinary frying steak, sales of the best grade decrease and sales of the ordinary grade increase (Figs. 3 and 4) as consumers switch from the more expensive into the less expensive grade. Similarly, as the price of best porterhouse rises compared with ordinary porterhouse, housewives substitute the cheaper grade for the premium product (Figs. 5 and 6). It could also be argued

FIG. 1

SALES AND PRICES OF FRYING STEAKS

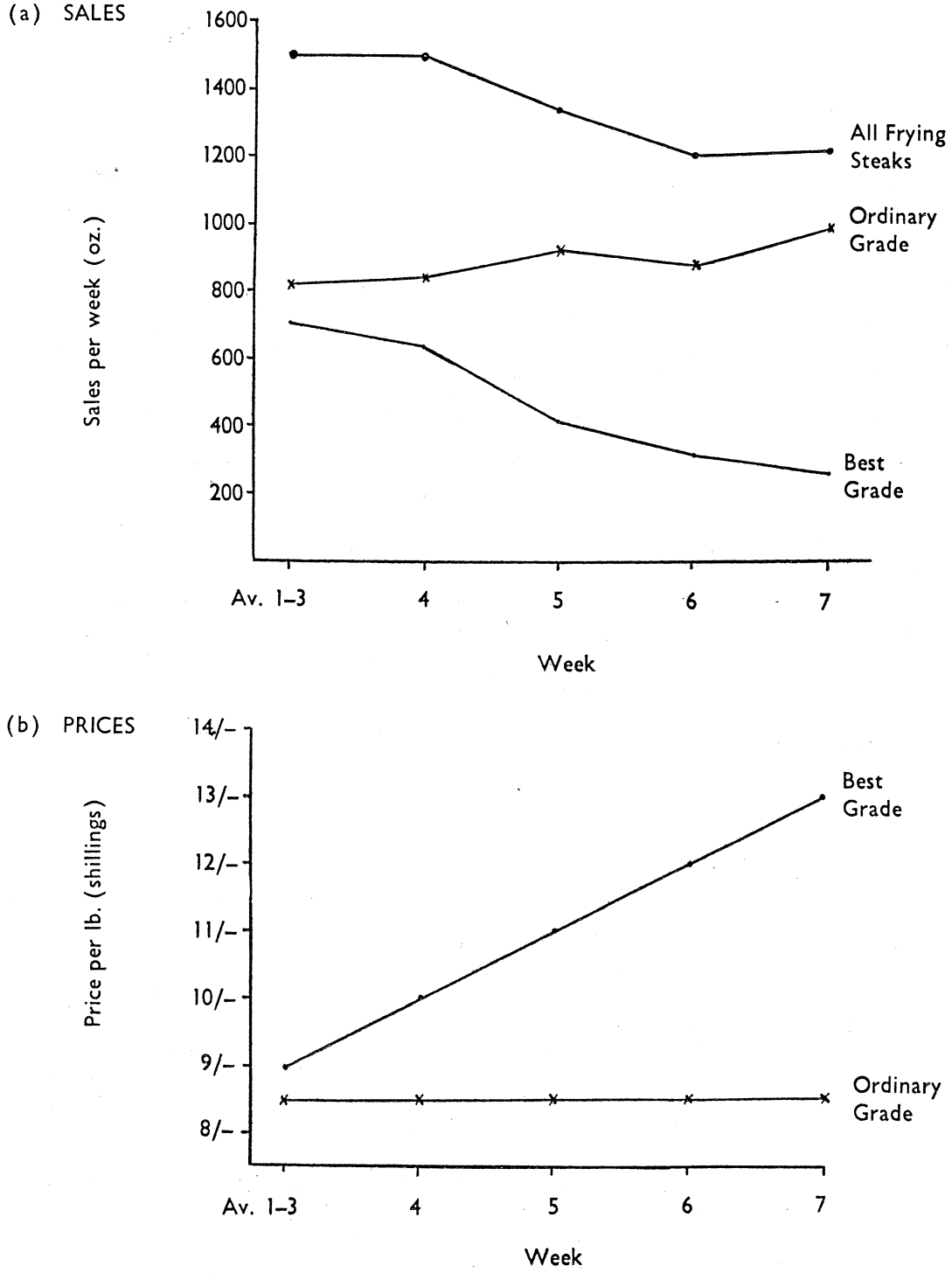
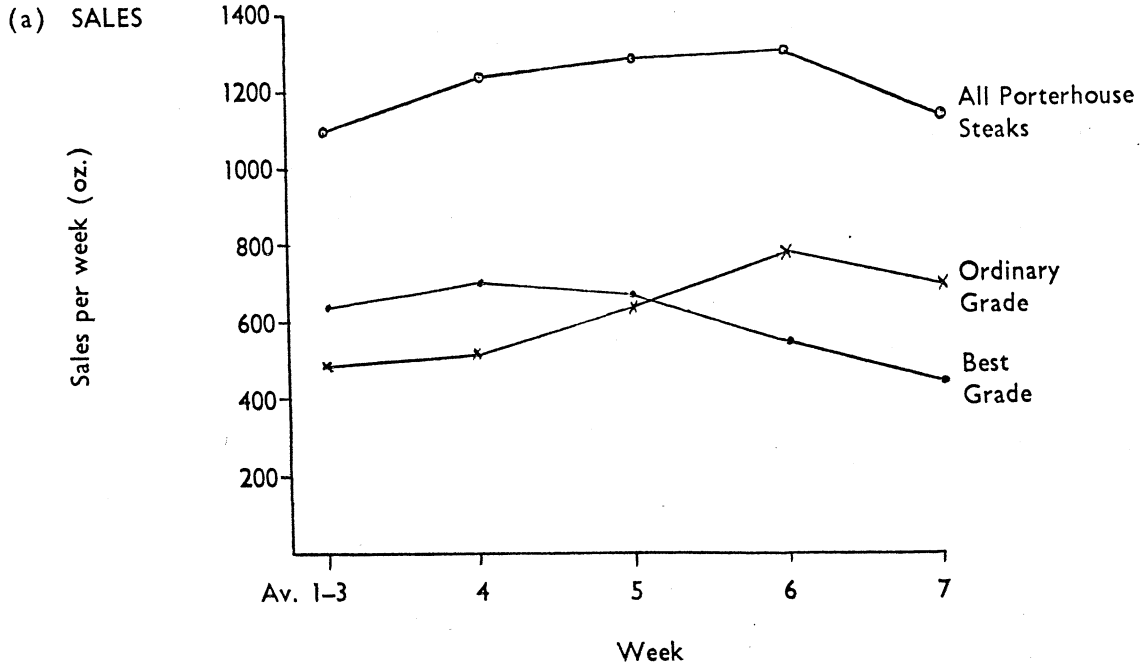


FIG. 2

SALES AND PRICES OF PORTERHOUSE STEAKS



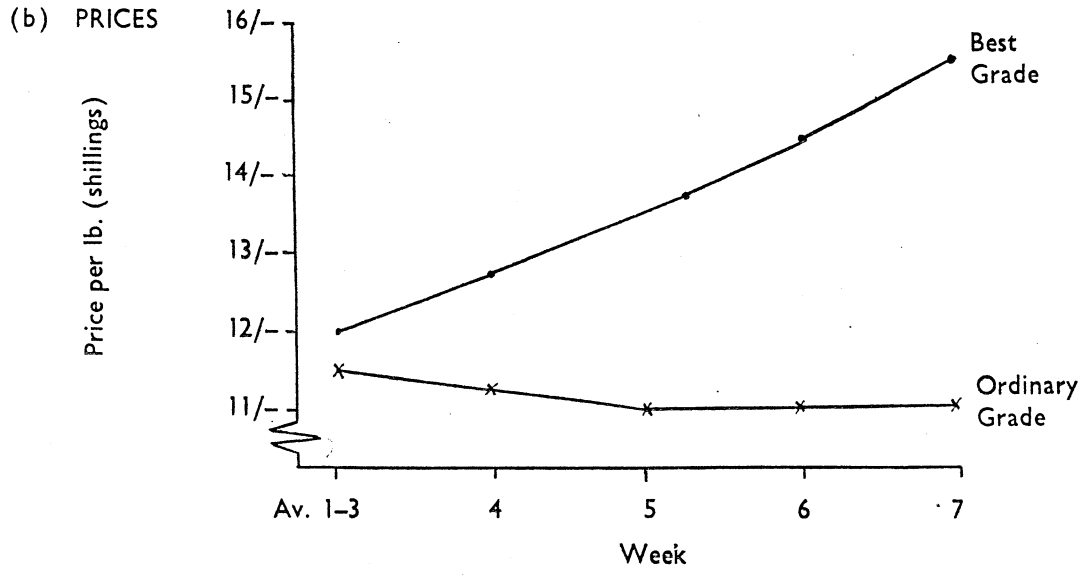


FIG. 3

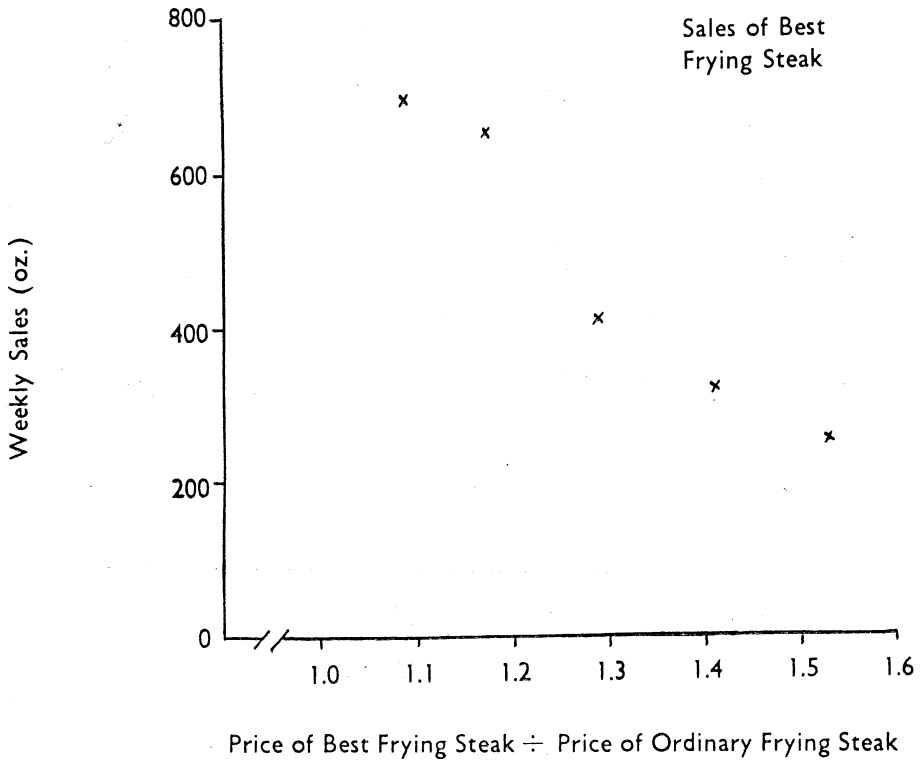

Sales of Best
Frying Steak
Weekly Sales (oz.)
800
600
400
200
0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
Price of Best Frying Steak ÷ Price of Ordinary Frying Steak

FIG. 4

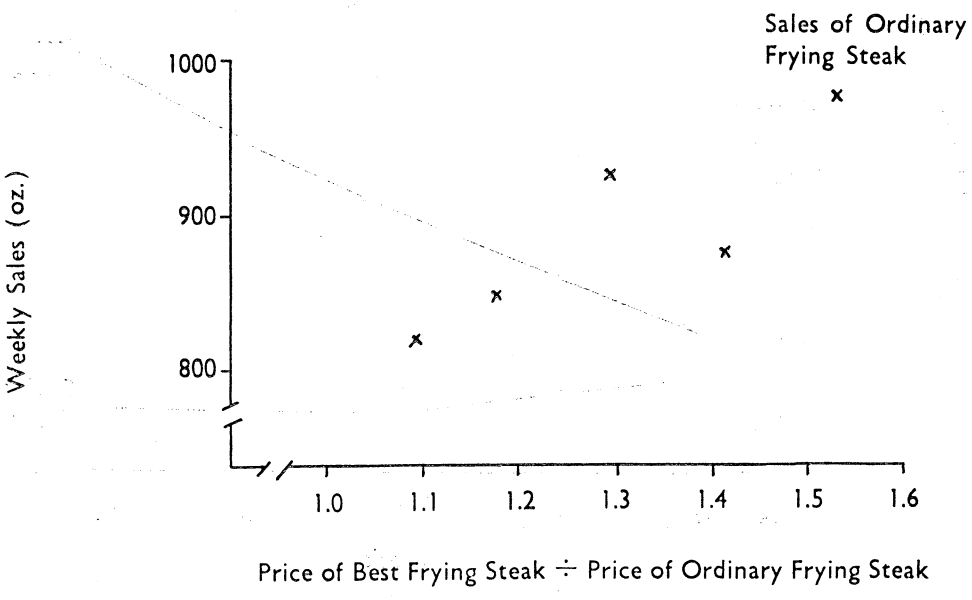

Sales of Ordinary
Frying Steak
Weekly Sales (oz.)
1000
900
800
1.0
1.1
1.2
1.3
1.4
1.5
1.6
Price of Best Frying Steak ÷ Price of Ordinary Frying Steak

FIG. 5

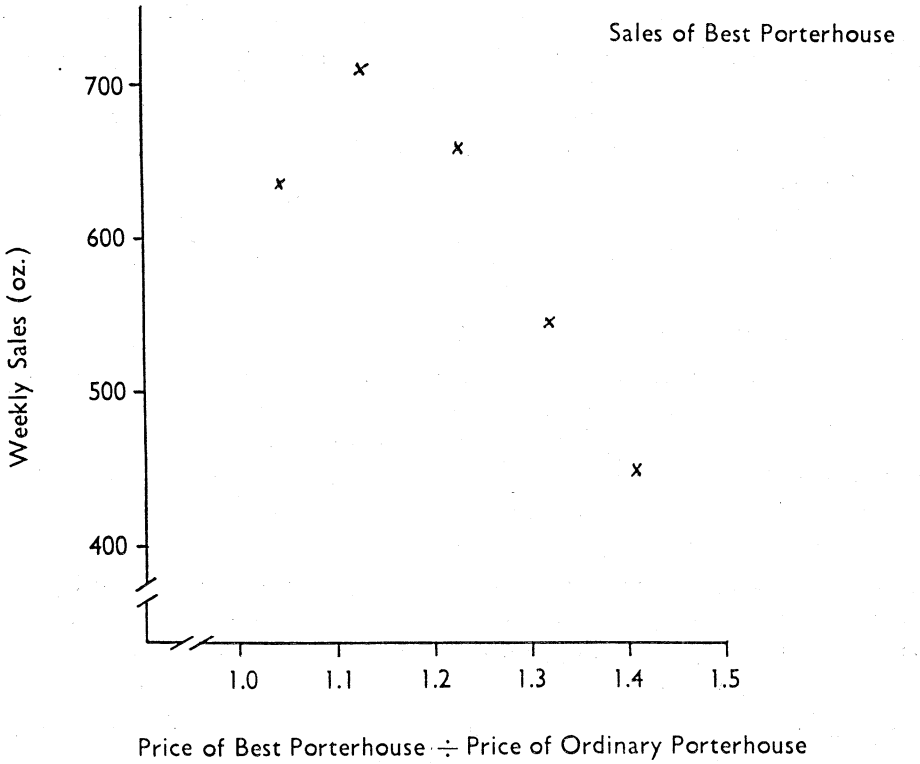
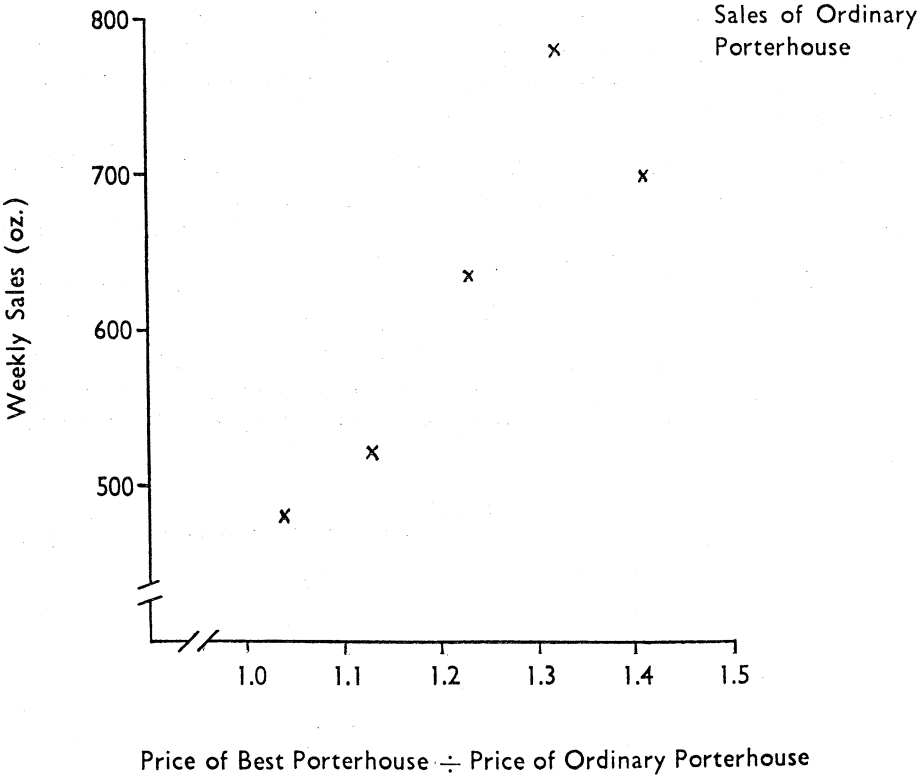

Sales of Best Porterhouse
Weekly Sales (oz.)
700
600
500
400
1.0
1.1
1.2
1.3
1.4
1.5
Price of Best Porterhouse ÷ Price of Ordinary Porterhouse

FIG. 6


Sales of Ordinary Porterhouse
Weekly Sales (oz.)
800
700
600
500
1.0
1.1
1.2
1.3
1.4
1.5
Price of Best Porterhouse ÷ Price of Ordinary Porterhouse

that consumers may in fact switch from porterhouse to frying steak, or from the best grade of one into the best grade of the other, in response to changes in the relative prices of the two cuts. Unfortunately, given the short period available for the experiment, it was not possible to design the test in a way which would facilitate statistical analysis of this particular form of substitution. In the following paragraphs we are only able to proceed on the simple assumption that

(i) best frying steak is a substitute for ordinary frying steak and that

(ii) the two grades of porterhouse steak also compete only against each other.

Premium Prices for Best Frying Steaks

Using the weekly summary data of sales quantities and prices for each category of frying steaks, a number of mathematical curves have been fitted in order to explain empirically the influence that the ratio of the two prices has on the quantity of each grade demanded by consumers. For example, for best frying steaks the mathematical relationship might take the form:

$$Q_2 = a + b\,(P_2/P_1) \qquad (1)$$

where Q_2 represents weekly sales of the best grade and P_2 and P_1 are the prices of the best and ordinary grades respectively. Similarly, for the ordinary grade the relationship between sales (Q_1) and the price ratio might be written as:

$$Q_1 = c + d\,(P_2/P_1) \qquad (2)$$

and in each case standard statistical techniques may be applied to determine the most plausible values of the parameters 'a', 'b', 'c' and 'd' given the empirical observations recorded in Figure 3 and Figure 4.

Once the relationships between quantities and relative prices are determined an attempt can be made to evaluate the price premium which should be charged for the better quality (i.e. more tender) grade of frying steak in order to achieve a given management objective.

In this particular experiment the price of ordinary frying steak was held constant at a level determined in relation to the overall commercial objectives of the store's butchery department. In this context it is worthwhile segregating the more tender steaks for sale at a higher price only if total turnover increases in comparison with a policy of selling all steaks at a common price. Admittedly, additional costs are incurred if the topsides are hung for a longer period in order to sell them at a premium. Such costs are, however, mainly composed of interest on working capital tied up in longer hanging for no more than one week and as such may be neglected if it is found that a substantial price premium for the better quality steaks maximises the total value of turnover.

Fitting linear relationships, of the form given in equations (1) and (2) above, to the scatters of observations recorded in Fig. 3 and Fig. 4 respectively we obtain:

$$Q_1 = 503.56 + 296.79\,(P_2/P_1) \qquad (1a)$$

$$\text{and } Q_2 = 1775.89 - 1012.06\,(P_2/P_1) \qquad (2a)$$

where Q_1 is the estimated quantity of ordinary frying steak sold (oz./week)
Q_2 is the estimated quantity of best frying steak sold (oz./week)
P_1 is the price charged for ordinary frying steak (shilling/lb.)
P_2 is the price charged for best frying steak (shilling/lb.)

Total estimated turnover of all frying steaks per week (Z) can be written as

$$Z = P_1 Q_1 + P_2 Q_2 \qquad (3)$$

and using equations (1a) and (2a) to substitute for Q_1 and Q_2 in the turnover equation (3) we obtain

$$Z = (503.56 + 296.79 [P_2/P_1]) P_1 + (1775.89 - 1012.06 [P_2/P_1]) P_2$$

But throughout the experiment the price of ordinary frying steak (P_1) was held constant at 8s. 6d. per lb., and substituting this value in the turnover expression we obtain:

$$Z = 4280.26 + 2072.68 P_2 - 119.0664 P^2_2 \qquad (4)$$

By elementary differential calculus it can be shown that the value of turnover (Z) in equation (4) is maximised when $P_2 = 8.662$ shillings/lb: that is when the price of best frying steak is fixed at approximately 8s. 8d. per lb., given a price for ordinary frying steaks of 8s. 6d. per lb. Assuming that 8s. 6d. is an equilibrium price for ordinary steaks, the optimum price premium for the more tender steaks is only about 2d. per lb., or in general around 2 per cent.

Acceptance of this conclusion is conditional upon a large number of assumptions. Firstly, the result depends upon the way in which the initial demand functions (equations [1] and [2]) are formulated. If one postulates non-linear relationships between quantity sold and price, for example,

$$Q_1 = a + b(1/P_2)$$
and $$Q_2 = c + d(1/P_2)$$

the empirical values of the parameters are estimated as:

$$Q_1 = 1264.01 - 4070.9(1/P_2) \qquad (5)$$
and $$Q_2 = -822.23 + 13935.3(1/P_2) \qquad (6)$$

If these results are used in the total turnover expression (equation [3]) for all frying steaks it is found that sterling turnover is maximised if no price premium is charged for the more tender frying steaks[10]. Although the latter equations, (5) and (6) are theoretically more pleasing as representative of demand equations, in a statistical sense the linear equation (1a) for ordinary frying steaks:

$$Q_1 = 503.56 + 296.79 (P_2/P_1)$$

and the non-linear equation (6) for best frying steaks

$$Q_2 = -822.23 + 13935(^1/P_2)$$

are the two which best fit the observed behaviour of consumers in this particular

(10) In fact, the 'best', but clearly unrealistic, value for P_2 is 6.487 shillings/lb. which is less than the price charged for ordinary frying steaks. The implication is that it is not worthwhile segregating steaks into two grades at the ruling price for the ordinary grade.

experiment. However, if these two equations are substituted in the total turnover equation it can again be calculated that no price premium should be charged for the best frying steaks in an optimum pricing strategy.

The obvious conclusion, that more tender steaks do not command any significant price premium at the retail level, must be treated with great caution. During the experimental period the less tender category comprised what would normally be considered to be very tender steaks, and we have noted that on some occasions the 'best' category was marginally less tender in spite of longer hanging periods. In any case, if all of the steak sold is very tender it is not surprising that housewives were unwilling to be tempted into buying steaks possessing additional tenderness. If it had been practicable to procure steaks for the less tender category possessing a shear value of more than 22 lb. it is quite possible that very different results would have been obtained. The only logical conclusion arising from this specific experiment is that if one normally retails very tender frying steaks total turnover is unlikely to increase if some of these are segregated into a grade labelled 'best' and sold at a premium: in short, the word 'best' does not have any commercial use if the normal practice is to sell very tender steak anyway.

Premium Prices for Best Porterhouse Steaks

Demand equations for each type of porterhouse steak on offer were estimated in a similar way as for the frying steaks. For some mathematical formulations of the relationship linking sales with relative prices the 'fit' of the equations to the observated data is less perfect. As a result the optimum price premium calculated for the best grade (leaner steak) over the ordinary grade depends to a great extent on the combination of equations selected for substitution in the total turnover equation.

Here we confine ourselves to the analysis of the two equations which best fit the data, and for which sales of each grade are assumed to be dependent upon the ratio of that grade's price to the price of the other grade:

$$Q_3 = 1557.21 - 1125.44\,(P_3/P_4) \qquad (7)$$

and $$Q_4 = 1338.50 - 603.18\,(P_4/P_3) \qquad (8)$$

where Q_3 is the estimated quantity of ordinary porterhouse sold (oz./week)

Q_4 is the estimated quantity of best porterhouse sold (oz./week)

P_3 is the price charged for ordinary porterhouse (shillings/lb.)

and P_4 is the price charged for best porterhouse (shillings/lb.)

Total estimated turnover of all porterhouse per week (Z) can be written as:

$$Z = P_3Q_3 + P_4Q_4$$

$$\text{or, } Z = 1557.21\,P_3 - 1125.44(P^2_3/P_4) + 1338.50\,P_4 - 603.18\,(P^2_4/P_3).$$

Setting the price of ordinary porterhouse (P_3) at 11 shillings/lb., a typical commercial price charged during the experimental period, it can be shown by differential calculus[11] that the value for P_4, the price of best porterhouse, which maximises consumer expenditure on sirloin steaks is 16.67 shillings/lb. This optimum price represents a premium of 5s. 8d. per lb., or 51.5% above the price charged for the fattier porterhouse.

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[11] Differentiating Z with respect to P_4 and solving the cubic expression after equating to zero.

This result is only optimal, however, if the objective is to maximise consumer expenditure on all sales of porterhouse. From the viewpoint of the butchery management this can seldom be a totally desirable objective since it fails to take into account any additional costs which may be incurred in making the leaner steaks available. Broadly, there are two such costs. Firstly, there are labour costs involved in further trimming of boned-out sirloin joints to enable sales at a premium price to occur. The marginal costs incurred, however, are likely to be small unless additional labour has to be recruited. Secondly, if the joint could have been sold in its fattier state at 11 shillings/lb., then further trimming for sale at a premium price involves the discarding of excess fat. The optimum price to be charged for the heavily trimmed meat should, therefore, take account of the value of the fat discarded and also of any revenue which may be obtainable for this.

For example, during the experiment steaks sold as ordinary porterhouse at 11 shillings/lb., typically exhibited a fat area of 32% whilst those sold as best porterhouse showed only 13% of their area to be fat. From calculations made below it can be shown that the additional trimming in this case would mean a loss of weight of saleable meat (lean plus fat) of approximately 16%. Consequently the turnover equation to be maximised can be written as

$$Z = P_3Q_3 + 0.84\ P_4Q_4$$

or when P_3 is 11 shillings/lb.,

$$Z = 17129.30 - 136178.24/P_4 + 1120.67P_4 - 45.91P^2_4$$

The value for P_4, the price of the leaner steaks, which maximises the value of this expression is 17.21 shillings/lb., yielding an optimum premium of 6s. 2d. over the price of the fattier steaks. This assumes that the discarded fat has no value and that the marginal costs of trimming are zero. During the experiment discarded fat from the butchery department was yielding a sale value of approximately 6d. per lb., though if the turnover equation is adjusted to take account of this the optimum premium is only little less than the 6s. 2d. per lb., already obtained.

During the experimental period the maximum price premium actually charged for the best grade of porterhouse was only 4s. 6d. per lb. Therefore, the optimum premiums calculated above extrapolate beyond conditions actually observed and imposed in the experiment. One cannot be certain that a marked cut-off in demand would not have occurred if a premium in excess of 4s. 6d. had been charged in the supermarket. As it is, it may seem surprising that consumers were willing to purchase nearly 28 lb. of best porterhouse containing 13% fat, in the last week of the experiment, at 15s. 6d. per lb; whilst sales of ordinary porterhouse, with a fat area of 32% and available at only 11s. per lb., amounted only to approximately 44 lb during the same week.

Thus, 36% of consumption of all porterhouse steak in the last week of the shop test was in the form of the heavily trimmed meat. One is therefore prompted to seek an economic rationalisation for housewives' willingness to pay such a high premium in order, fundamentally, to avoid trimming the fattier meat in their own kitchens.

In order to do this small samples of porterhouse and best porterhouse steaks were photographed in order to measure their areas of fat and lean, and the same steaks were dissected in order to weigh their fat and lean content. Using a linear relationship between fat weight as a percentage of total weight (Y) and fat area as a percentage of total area (X) the least-squares equation took the form:

$$Y = 0.0675 + 0.8466\,X$$

$$(r = 0.7333,\ n = 15)$$

Strictly speaking the relationship should be curvilinear, though within the range of observations likely in practise a linear fit is a reasonable approximation. Accepting this relationship, the implication is that a steak weighing one pound, and with a fat area of 32% visible to the buyer, contains

$$[0.0675 + 0.8466(32)] / 100 \text{ lbs. of fat,}$$

or approximately 4.35 oz. of fat and 11.65 oz. of lean meat. In the same way, a one pound steak with a fat area of 13% contains approximately 14.23 oz. of lean meat. As a result, for the extreme consumer who eats only the lean meat and discards all of the fat as valueless, the economic price premium which can be justified for the leaner steak is

$$\left(\frac{14.23}{11.65} \times 100\right) - 100 \text{ per cent,}$$

or approximately 22.1% above the price which the same customer would have been prepared to pay for the fattier steak. The size of the premium which can be justified by consumers who like some fat rather than none is, of course, correspondingly smaller. Any additional premium which the customer is willing to pay can only be attributed to a combination of psychological factors, including dislike of meat trimming at home, and lack of knowledge or awareness of the visual characteristics of the meat being purchased.

In a similar way it is possible to calculate the minimum price premium which butchers must seek in order to make it financially worthwhile trimming additional fat from the sirloin joint. Suppose that after boning and trimming a sirloin joint weighs 10 lb. and can be sold as porterhouse steaks, with a fat area of 32%, at 11 shillings/lb., yielding a revenue of £5 10s. 0d. If the same joint is trimmed to be sold as steaks with a fat area of only 13% the total weight of saleable meat falls to 8.37 lb. whilst the remaining 1.63 lb. comprises discarded fat. If the discarded fat has no value and if the marginal costs of the additional trimming are zero then the price per pound charged for the heavily trimmed steaks must be at least

$$\left(\frac{10}{8.37}\right) \times 11 \text{ shillings, or 13s. 2d. per lb.,}$$

if the total return on the joint is again to be £5 10s. 0d. This represents a percentage price premium of 19.4% and must be regarded as a minimum economic premium, unless the discarded fat has some other use.

SUMMARY

The experiment which is reported here arises directly from the earlier consumer research undertaken by the Department of Agricultural Marketing in the University of Newcastle.

Certain characteristics of beef steaks, notably tenderness and leanness, had been identified as important in consumers' estimates of quality. Thus, it was shown that not more than 15 per cent of consumers are likely to require sirloin steaks with more than about 30 per cent of visible fat and that frying steaks from the round which give a Warner Bratzler shear reading of up to 22 lbs. will be sufficiently tender to be liked, at least moderately, by over 70 per cent of consumers. Such absolute preferences, however, have little meaning unless they are considered in relation to prices which can be charged for different qualities. The main objective of this particular investigation, therefore, was to determine to what extent consumers are likely to be willing to pay for more tender and leaner beef steaks.

In order to examine the effect of differential pricing on sales of more tender beef, steaks from the round were again used. For the leanness tests sirloin steaks were employed. The experiment took place in a large north London supermarket during seven weeks of late autumn and winter of 1966. During this period the experimental steaks were the only ones of their type sold in this store, though quick-frying, fillet and rump steaks were available in the display. The procedure was to offer in the normal meat display a choice between two groups of steaks from the round and two groups of sirloin steaks. The steaks from the round were described as "frying steak" or "best frying steak", according to their estimated degree of tenderness. Those from the sirloin were described as "porterhouse" and "best porterhouse steak", according to their estimated degree of leanness. The four groups were displayed separately and the price per lb. clearly marked on the facings and on each pre-pack. Broadly, during this shop test the price of the ordinary grades of both frying and porterhouse steak were kept at the commercial levels which the supermarket would have normally charged. The best grades were offered at a premium of 6d. per lb. during the first three weeks and thereafter this premium was increased steadily, at weekly intervals, until the end of the experiment.

The experiment with steaks of different degrees of tenderness failed in its main objective. Unfortunately, the technique, successfully tried beforehand in the laboratory, for obtaining steaks of different degrees of tenderness did not produce the same results during the test period. In the event both the ordinary and best frying steaks, in most weeks, had average shear values which indicated comparatively tender meat and on several days the ordinary steaks were more tender than the best. The results, therefore, only really show the effect of separating frying steaks, all reasonably tender, into two categories one of which is labelled "best" and sold at a premium. Not surprisingly it was found that total turnover is unlikely to increase in these circumstances.

The same material was used for ordinary and best porterhouse steaks; the difference in fat content being obtained by trimming. During the last four weeks of the experiment, when the price premium was being regularly increased, the porterhouse steaks had approximately 30 per cent and the best porterhouse steaks approximately 13 per cent of visible fat. The final premium charged for best porterhouse was 4s. 6d. per lb. more than for the ordinary steaks. Despite this, sales of best porterhouse steaks had only declined from a maximum of about 44 lbs. in the fourth week to 28 lbs. at the end of the period, compared with ordinary porterhouse steak sales during the same week amounting to 44 lbs. Since the steaks only differed in fat proportion, this strongly suggests that a large minority of consumers are prepared to pay for their preference for lean meat. Moreover, it can be calculated that a consumer who required no fat at all would only be justified in paying a premium for such a steak of 22 per cent above the price of the fattier steaks. The premium of 4s. 6d. per lb. is over 40 per cent above the price of the fattier steaks and was paid for steaks with about 13 per cent of visible fat. This may, therefore, indicate that consumers are willing to pay for some less obvious satisfactions including avoiding trimming in the home, or that they are unable, visually, to estimate differences in fat content and relate these to price in the store.

Calculations of the optimum premium to be charged by the retailer for the best porterhouse steaks in order to maximise revenue gave a result of 6s. 2d. per lb. Since this is an extrapolation beyond the observed data, it should be treated with some caution, as there might have been a sudden fall in purchases if the price had been raised to this level. Nevertheless, it does suggest some possible financial advantage to retailers in distinguishing clearly first and second qualities, and charging quite high premiums for the best, provided the difference can be recognised by the customer.

APPENDIX A

DAILY SALES SUMMARIES

(oz. sold, rounded to nearest oz.)

ORDINARY FRYING STEAK

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Friday	306	221	266	219	277	265	306
Saturday	125	116	88	108	161	123	135
Tuesday	128	113	135	103	106	190	136
Wednesday	117	65	142	193	158	37	168
Thursday	237	207	178	224	228	260	229

BEST FRYING STEAK

Friday	241	188	162	72	138	130	132
Saturday	184	156	142	87	129	41	43
Tuesday	43	60	43	174	23	24	7
Wednesday	60	68	155	135	55	49	17
Thursday	156	212	215	175	70	77	61

ORDINARY PORTERHOUSE

Friday	134	126	194	131	277	255	222
Saturday	26	81	94	119	121	145	116
Tuesday	87	49	25	120	107	160	151
Wednesday	69	88	85	70	39	87	70
Thursday	177	109	96	100	92	142	141

BEST PORTERHOUSE

Friday	91	169	250	75	222	177	182
Saturday	68	176	173	222	135	87	46
Tuesday	135	74	83	118	132	86	96
Wednesday	76	161	103	144	37	81	62
Thursday	131	137	87	152	136	109	61

APPENDIX B

PRICE ELASTICITIES AND ECONOMETRIC PROBLEMS

This appendix examines briefly the adequacy of the experiment as a source for data on which to base valid consumer demand relationships, and comments on the estimates of price elasticities derived from those data. The comments are somewhat technical and these paragraphs have been separated from the main text in order to improve the readability of the latter.

Since supplies of the experimental steaks were always available at the predetermined prices (i.e. the elasticities of supply were infinite) it is reasonable to assume that relationships expressing the quantity of sales as a function of prices approximately represent statistical demand functions. In practise the only functions actually estimated using weekly data were:

$$Q_1 = f(P_2)$$
$$Q_2 = f(P_2)$$
$$Q_3 = f(P_3/P_4)$$
$$Q_4 = f(P_4/P_3)$$

where (i) Q_1, Q_2, Q_3, and Q_4 are quantities sold (oz.) of ordinary and best frying steak, and ordinary and best porterhouse steak respectively, and (ii) P_1, P_2, P_3 and P_4 are the prices of the four categories of steak in the same order.

The possible shortcomings of such models, whether written in terms of the original or transformed variables, are obvious. For example, no account is taken of possible substitutions between frying steaks and porterhouse steaks, or between these and other cuts of meat available in the store. Secondly, all variables are current and it is therefore not feasible to examine the possibilities of lagged responses to price changes. In the same way, it is implicitly assumed that other cuts of meat, outside the control of the experiment, were also continuously available at their listed prices. Given the short period available for the experiment it was clearly not possible to use multivariate analysis, for two reasons. Firstly, insufficient weekly observations were available in order to gain sufficient degrees of freedom, bearing in mind that all prices were held constant during the first three weeks of the seven-week test period. Secondly, there is an almost perfect correlation between the prices of the best frying and best porterhouse steaks, whilst the prices of the ordinary grades were either held constant throughout the experiment (as with best frying steak) or only varied a little (as with best porterhouse) in response to normal commercial criteria imposed by the store. Inevitably, any attempt to analyse the degree of substitution of porterhouse for frying steaks would have failed due to collinearity amongst the independent price variables. This could only have been avoided by extending the experiment over several more weeks, but extension in this way would possibly have led to violation of some of the *ceteris paribus* assumptions which have been made about the external environment.

Despite the necessary omissions the bivariate models described above (using current variables and assuming absence of lagged responses) appear to explain consumer behaviour reasonably well. The characteristics of the regressions presented in the report are as follows:

(1a) $Q_1 = 503.56 + 296.79\ (P_2/P_1)$
(100.46) $r = 0.8627$

(2a) $Q_2 = 1775.89 - 1012.06\ (P_2/P_1)$
(136.30) $r = -0.9739$

(5) $Q_1 = 1264.01 - 4070.9\ (1/P_2)$
(1392.0) $r = -0.8604$

(6) $Q_2 = -822.23 + 13935.3\ (1/P_2)$
(1832.1) $r = 0.9750$

(7) $Q_3 = 1557.21 - 1125.44\ (P_3/P_4)$
(307.62) $r = -0.9038$

(8) $Q_4 = 1338.50 - 603.18\ (P_4/P_3)$
(233.23) $r = -0.8309$

In all cases the signs conform with conventional economic expectations about consumer behaviour although for three equations the standard errors of parameters are rather higher than would normally be accepted*.

Weekly own-price elasticities of demand can be estimated for the best frying and best porterhouse steaks, and these are all greater than unity, as expected:

Equation	Category	Price Elasticity**
(2a)	Best Frying Steak	−2.81
(6)	Best Frying Steak	−2.72
(8)	Best Porterhouse Steak	−1.22

(**Elasticities are computed at the means)

The low own-price elasticity for best porterhouse reflects the unwillingness of consumers to switch to the fattier grade of porterhouse even when the best category carries a high price premium. For the two ordinary grades of steaks there are insufficient data on which to base meaningful own-price elasticities.

Using the daily data summarised in Appendix A a similar attempt has been made to compute own-price elasticities for the two best grades of steaks for each day of the week. For each category a multivariate model was established, incorporating zero-one variables to permit daily shifts in the intercept term and interaction variables allowing daily changes in the slope coefficient. Unfortunately, few of the parameters have any statistical significance due to capricious movements in day-to-day sales within a week, although the daily demand functions derived from the multiple regression do in all but one case exhibit the expected signs:

*In each case there are only 5 pairs of observations; vis. the average sales and price for the first three weeks together with weekly data for the four subsequent weeks.

BEST FRYING STEAK (Q_2)

Day	*Equation*	*Own-price elasticity at means*
Friday	$Q_2 = 213.05 - 7.20\ P_2$	−0.59
Saturday	$Q_2 = 402.00 - 28.20\ P_2$	−3.38
Tuesday	$Q_2 = 311.96 - 23.33\ P_2$	−4.64
Wednesday	$Q_2 = 333.22 - 23.94\ P_2$	−3.77
Thursday	$Q_2 = 505.67 - 36.39\ P_2$	−3.47

BEST PORTERHOUSE STEAK (Q_4)

Day	*Equation*	*Own-price elasticity at means*
Friday	$Q_4 = -9.39 + 142.36\ (P_4/P_3)$	+1.05
Saturday	$Q_4 = 559.03 - 353.53\ (P_4/P_3)$	−3.41
Tuesday	$Q_4 = 151.42 - 37.27\ (P_4/P_3)$	−0.43
Wednesday	$Q_4 = 308.65 - 180.44\ (P_4/P_3)$	−2.51
Thursday	$Q_4 = 326.72 - 172.27\ (P_4/P_3)$	−1.81

The extent to which valid comment can be made is severely limited, except that on Fridays it appears that consumers are particularly unresponsive to price changes.

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