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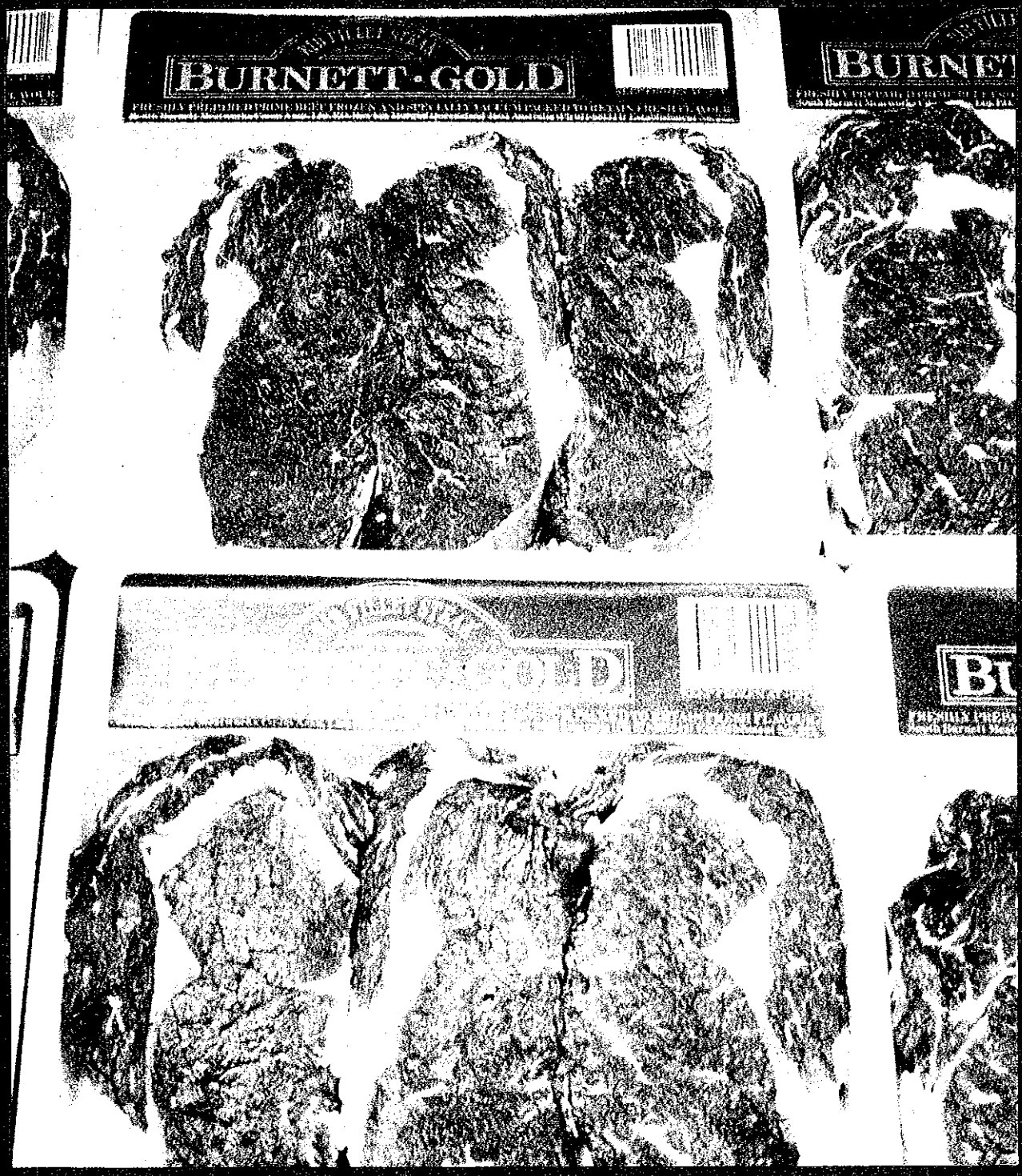

Effect of can rotation during retorting on retention of colour in canned green beans

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Green beans were processed in 83 x 90 mm cans at 122°C. Spinning the cans during processing increased the rate of heat penetration as measured by f_h and changed the shape of the heat penetration curve. Reducing the ratio of beans to brine from 1.6 to 0.83 reduced the f_h for stationary cans from 4.1 to 2.9 min. Spinning the cans with the low ratio of beans to brine further reduced the f_h from 2.9 to 1.0 min. Beans processed to F_o = 3.5 min in spinning cans retained more of their bright green colour than beans processed to F_o = 3.5 min in stationary cans. The colour differences indicate that the process based on spinning cans converts about 26% of the chlorophyll while 38% of the chlorophyll is converted in the stationary process.

Introduction

When green beans *(Phaseolus vulgaris L.)* are sterilized their colour changes from the incipient bright green to an olive-green. The colour change results from the conversion of chlorophyll to pheophytin. MacKinney and Weast (1940) found the reaction in aqueous acetone to be first order with respect to both acid and chlorophyll. The loss of chlorophyll can be estimated from measurements of colour difference using the tristimulus Lab system. Epstein (1959) used the colorimetric ratio -a/b to represent the "greenness" of the vegetables. Gold and Weckel (1959) studied the reaction in canned green peas and found that there was good correlation between the ratio -a/b and the concentration of chlorophyll. The empirical relationship between the loss of chlorophyll and the ratio -a/b (which was incorrectly cited in the paper by Hayakawa and Timbers (1977)) is:

% loss of chlorophyll = [(a/b) – 0.931]/0.00747

Green beans are processed by one Australian manufacturer in continuous reel retorts. During processing in these retorts the cans spin with their cylindrical axis horizontal as they roll over the base of the cylindrical retort shell. The retort manufacturer claims the cans roll for about 100° of arc in each loop of the spiral but for this investigation it was assumed the cans only rolled for 60° of arc.

The rate and time that the cans spin depends on the process time, the number of spirals in the retort, the internal diameter of the retort and the external diameter of the can. The time that a can rolls as it passes through each loop of this spiral, and the rate of spinning of the can as it rolls may be calculated from equations 1 and 2 respectively.

$$t_s = B/(6.N) \quad \ldots 1$$

$$R = D.N/(B.d) \quad \ldots 2$$

where t_s is the time that each can rolls per loop of the spiral (min),
B is the process time (min),
N is the number of spirals in the retort,
R is the rate of spinning (r/min), of the can as it rolls
D is the internal diameter of the retort (mm),
and d is the external diameter of the can (mm).

If cans of beans are processed without agitation the product may suffer an unnecessary loss of organoleptic quality visible as a loss of green colour.

Although retention of chlorophyll during thermal processing does not guarantee a better coloured product during storage, it is an indicator of the retention of other quality factors such as vitamins and textural properties.

This report describes heat penetration experiments on canned green beans in which the effects of the fill mass of beans and the rate of spinning of the cans were examined. Two processes based on the data obtained from these experiments were applied to green beans and the effect of the processes on the colour of the beans was examined.

Materials and methods

The beans were supplied by Golden Circle

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Cannery, Northgate, Queensland, washed, cross cut into pieces about 20 mm long, 8 mm diameter (0.7 g mass) and blanched.

Can temperatures were measured and logged using a HP3054 data-logger and type T thermocouples placed in the geometric centre of each can. The 83 x 90 mm GP2 lacquered cans were prepared by soldering a copper tube, 3 mm ID x 5 mm, to the centre of the can-maker's end. The thermocouples were sealed into each copper tube with an epoxy resin (Araldite 24 h set).

The cans were filled with:

A. 280 g beans, 10 g over the maximum filling weight, and 172-175 g of 2.5% brine. These cans were processed with intermittent spinning at 93 or 137 r/min to simulate conditions in a continuous reel retort of 1350 mm internal diameter when the spiral was rotating at 5.7 or 8.4 r/min.
B. 270 g of beans and 170 g of 2.5% brine. These cans were processed stationary and while spinning continuously at 50 and 100 r/min.
C. 200 g of beans and 240 g of 2.5% brine. These cans were processed stationary and while spinning continuously at 50, 100, 150 and 200 r/min.

All cans were processed in a small experimental retort 330 mm diameter x 850 mm length which was fitted with an axially placed, perforated cylinder to hold and rotate the cans during processing.

Within 24 h of processing the beans were drained and pureed in a laboratory blender for 40 s, care being taken to avoid inclusion of air in the puree. The colour of the puree was measured immediately using a Minolta Chroma Meter II (reflectance) colour difference meter. The L, a and b values were determined four times on each sample and the average of the four readings was recorded.

Results

Experiments coded A were carried out to simulate the conditions in a continuous reel retort and they gave heat penetration curves which were concave when plotted semi-logarithmically (Fig. 1). The initial slope of the heating curve (f_h) increased from about 2.7 min to more than 6 min per log cycle of temperature difference after 10 min of heating. A conservative estimate of f_h and of j, the lag factor, was made by drawing a straight line touching the curve near the one minute mark and the point where the temperature difference was just less than 1 K (zero on the log scale). The results of these conservative estimates are summarized in Table 1.

Although the come-up-time for the experimental retort was less than 1.2 min, j values were corrected (Stumbo 1973) because the heat processing data being measured were to be used to calculate processes for continuous reel retorts where each can is delivered directly into the steam atmosphere through a rotating port.

Experiments coded B were carried out on a can filled to the usual maximum level and ratio of beans to brine. The f_h value of 2.8 min for stationary cans was about 25% lower than the f_h for overfilled cans in the A experiments and was further reduced, but not greatly, by spinning the can. The relative ineffectiveness of spinning probably arose from the beans forming in a structure in the can which inhibited the circulation of brine.

In experiments coded C the cans were filled with 200 g of beans and 240 g of 2.5% NaCl brine. The beans and brine in these cans had more room to move unlike those in experiments coded A and B. Cans which were stationary during processing had an f_h of about 3.0 min, about the same as the cans in the B series but lower than the cans in the A series. Spinning cans in experiment C reduced the f_h to a minimum of about 1 min at 100 r/min (Fig. 2).

The shape of the heat penetration curve was consistently concave for stationary processes and convex for processes during which the cans were continuously spun. The concave nature of the heat penetration curve arises because the rate of heat transfer falls as the temperature inside the can approaches the retort temperature. The rate of heat transfer depends on the convective currents inside the can and natural convection arises from the temperature differences across the can. As the can temperature increases the natural convection decreases and this in turn is reflected in lower

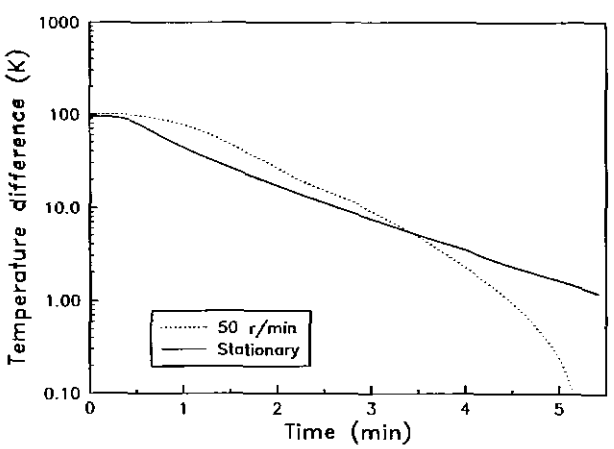

Fig. 1. Heat penetration curves for canned green beans with and without spinning.

TABLE 1

Results of heat penetration experiments for canned green beans

Experiment series	Mass of beans per can (g)	Mass of brine per can (g)	Speed of rotation (r/min)	j value	f_h value (min)	Shape of curve
A	280	175	93[A]	1.15	3.8	Concave
A	280	175	93[A]	1.09	3.6	Concave
A	280	175	93[A]	1.07	4.2	Concave
A	280	175	93[A]	1.06	4.1	Concave
A	280	175	93[A]	1.11	4.1	Concave
A	280	175	137[B]	1.00	3.7	Concave
A	280	175	137[B]	1.14	3.2	Concave
B	270	170	0	1.00	2.8	Concave
B	270	170	50	1.17	2.0	Convex
B	270	170	100	1.91	2.1	Convex
C	200	240	0	1.12	2.9	Concave
C	200	240	0	1.08	2.4	Concave
C	200	240	50	1.09	1.5	Slightly convex
C	200	240	50	1.00	1.8	Slightly convex
C	200	240	100	1.98	1.1	Very convex
C	200	240	100	1.04	1.0	Very convex
C	200	240	150	1.49	1.4	Very convex
C	200	240	150	1.26	1.7	Very convex
C	200	240	200	0.97	1.8	Very convex
C	200	240	200	1.13	1.8	Very convex

[A]Cans spun every 10.2s for 1.6s
[B]Cans spun every 6.5s for 1.1s

rates of heat transfer and concave heat penetration curves. When the brine is stirred by spinning the can the rate of heat penetration increases as the viscosity of the brine decreases. As the can temperature increases the viscosity of the brine decreases allowing more effective stirring and the rate of heat penetration increases. The heat penetration curves under these forced conditions are characteristically convex.

Since all the heat penetration curves for the series A experiments were concave heat transfer was predominantly through natural convection even though the cans were spun for short periods during the process.

The increased rate of heat transfer caused by mechanical stirring in experiment C reduces the processing time needed to commercially sterilize the beans. The fastest rate of heat transfer occurred when the cans were spun at 100 r/min where f_h was 1.0 min. The slowest rate of heat transfer was for a stationary process.

The rate of heat penetration decreased as the rate of spinning of the cans increased from 100 to 200 r/min. At these higher speeds the headspace bubble moves towards the axial centre of the can and reduces its stirring action.

While a process of 7.3 min at 122 °C was needed to sterilize stationary canned beans to F_0 = 3.5 min, only 4.4 min at the same temperature was required to obtain the same F_0 value in cans spinning at 100 r/min.

These processes were given to cans of green beans and the destruction of chlorophyll was measured.

The average of four colour readings for the unprocessed beans, beans which had been

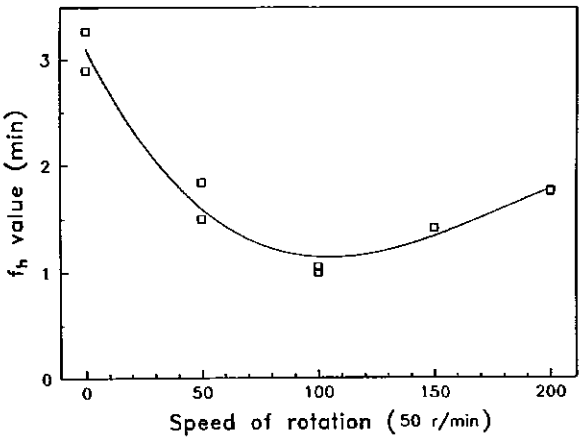

Fig. 2. Effect of the speed of can rotation on the f_h value for green beans.

TABLE 2

Tristimulus colour readings[A] of unprocessed and processed green beans

Treatment	L	a	b	-a/b
Unprocessed	49.1	-16.0	21.2	0.757
Stationary process	42.5	-9.7	20.7	0.472
Spun (100 min) process	41.7	-11.7	20.0	0.563

[A]Average of four readings.

processed in stationary cans and beans processed at 100 r/min are presented in Table 2.

Hayakawa and Timbers (1977) found that the destruction of chlorophyll in green beans was temperature dependent with z = 38.9 K; z is the number of degrees for the rate of conversion of chlorophyll to decrease by 90%. The relative amount of chlorophyll destroyed by the processes given to the beans can be evaluated using the published value of z estimated in terms of $F^{121.1}_{38.9}$ or equivalent time at 121.1°C. The F value gives an estimate of the severity of the two processes with respect to chlorophyll destruction; for the stationary process $F^{121.1}_{38.9}$ = 4.7 min while for the process in which the cans were spun at 100 r/min the $F^{121.1}_{38.9}$ = 3.6 min.

Both these processes had F_o = 3.5 min. $F^{121.1}_{38,9}$ values were plotted on semi-log paper against time of heating and the slope of the line indicated that heating for about 22 min at 121.1°C would reduce the colour, as measured by -a/b to one-tenth of the original value. This compares well with the value of 18 min estimated from the data of Hayakawa and Timbers (1977).

An estimate of the percentage destruction of chlorophyll can be made using the equation of Gold and Weckel (1959), modified to account for the initial colour of the green beans. About 38% of the chlorophyll was destroyed in the stationary process and 26% was destroyed when the cans were spun at 100 r/min.

These results can be used to estimate the effect of altering retort temperature on the destruction of chlorophyll in canned green beans. Table 3 presents estimates of the expected losses of chlorophyll for three processes at four retort temperatures. The three processes are:

A. Cans filled with 280 g beans, 170 g brine, f_h = 4.1 min which is equivalent to the process applied in the continuous reel retort.
B. Stationary cans filled with 200 g beans, 240 g brine, f_h = 2.9 min.
C. Cans spinning at 100 r/min filled with 200 g beans and 240 g brine, f_h = 1.0 min.

All processes gave an F_o = 3.5 min.

The losses of chlorophyll at 116°C are about 66% and were reduced to 61% by using process C. Processing at 125°C however, reduced the losses of chlorophyll to 37% and

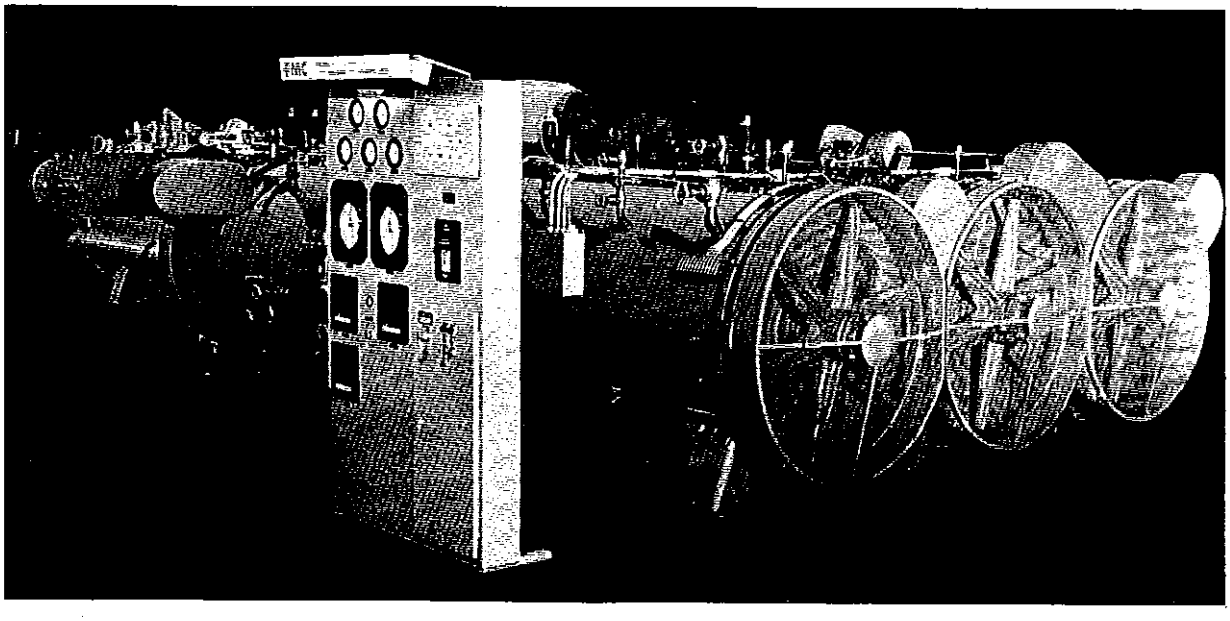

Fig. 3. Continuous rotary pressure cooker.

TABLE 3

Estimated losses of chlorophyll in canned green beans processed to F_0 = 3.5 min at four retort temperatures by three procedures methods

Process	Retort temperature (°C)	Process time (min)	$F^{121.1}_{38.9}$ (min)	Colour ratio (-a/b)	Loss of chlorophyll (%)
A	116	17.6	10.2	0.26	66
B	116	15.8	9.6	0.28	64
C	116	12.9	8.8	0.30	61
A	122	9.0	5.4	0.43	44
B	122	7.3	4.7	0.46	40
C	122	4.4	3.6	0.52	32
A	125	7.3	4.3	0.48	37
B	125	5.7	3.7	0.51	33
C	125	3.0	2.5	0.58	24
A	130	5.7	3.3	0.54	30
B	130	4.3	2.7	0.57	25
C	130	1.9	1.6	0.64	16

[A]Process for a can filled with 280 g of beans, 175 g of brine and spun at 93 r/min for 1.6 s every 10.2 s

[B]Process for a can filled with 200 g of beans, 240 g of brine and held stationary

[C]Process for a can filled with 200 g of beans, 240 g of brine and spun at 100 r/min.

spinning the cans further reduced the losses to 24%.

These results show that spinning cans of beans during retorting reduces the severity of the process needed to achieve commercial sterility. The improvement in colour immediately after processing does not guarantee a greener product on the shelf because the conversion of chlorophyll to pheophytin continues at room temperature in the can. Nevertheless the destruction of other quality factors such as vitamins and texture would be lessened with the shorter processes.

The reduction in f_h by spinning cans with a low ratio of beans to brine is not sufficient to warrant manufacturers altering their processing and packaging (for example, by increasing the ratio of brine to beans) because raising the temperature and reducing the time of processing is a more effective and cheaper method of preserving the quality of canned beans.

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Fat content of popular cuts of meat: cooked and raw[1]

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Introduction

Australian meat consumption has traditionally been high. Even in recent times the annual consumption of meat has been approximately 100 kg per capita, as indicated by Australian Meat and Livestock Corporation statistics on carcass meat disappearance (Fantini and MacDonald 1987). The relationships between diet, nutrition and health are receiving increased attention in affluent countries, including Australia. Increased amounts of fat in the diet have been related to obesity and, on the basis of epidemiological data and some experimentation on animals and humans, to the increased incidence of both coronary heart disease and some cancers.

Dietary guidelines for Australians have recommended to 'avoid eating too much fat' (English 1983). However, as a result of inadequate and sometimes inaccurate media reports, and the forceful opinions of some individuals and vocal minorites, there seems to have arisen a strong perception that 'red meat' consumption is equated with a high fat intake and, therefore, a high health risk. Some groups consider that 'red meat' in the diet is unsatisfactory, but 'white meat' (chicken and fish for example) is acceptable.

Furthermore, the data on the fat content of meat presented in 'Metric tables of composition of Australian foods' (Thomas and Corden 1977) or by Cashel (1985) are largely drawn from British or American sources. If these values are used, meat does make a major contribution to the fat content of the diet of Australians (English 1983). However, recent studies by Sinclair on raw meat (Sinclair *et al.* 1982, Sinclair *et al.* 1985) 'indicate a lower intramuscular lipid content for beef than the values found in British, American and Australian Tables of Food Composition'. Against this background and the fact that there is a paucity of information on the fat content of meat actually eaten by Australians, a study of the fat content of popular cuts of beef, lamb and chicken in their raw and cooked states was undertaken.

[1] Based on an address to the 19th AIFST Convention, Brisbane, 1986.

Materials and Methods

Meat Source

The beef, lamb and frozen chickens studied came from a local butcher shop. Fresh chickens came from a local barbecued chicken store.

Beef

Twenty-four each of T-bone steaks, rump steaks, and blade steaks, and eight topside roasts were selected from eight carcasses (each approximately 200 kg) branded with a gold stripe (indicating electrically stimulated carcasses, from animals of the 7 tooth or less age group, with not less than 3 mm of fat cover over the rump). Adjacent slices of steak (in groups of three, each slice approximately 2 cm thick) were selected from the mid-section of chosen cuts. The centre slice from each group was analysed raw and the remaining two following cooking (one grilled and one pan-fried).

Topside roasts (approximately 2 kg each) were divided into halves. One half was analysed raw and the other half following roasting.

Lamb

Loin chops (24 small and 24 large; based on eye muscle area) and eight rolled shoulder roasts were selected from 16 trade lamb carcasses (approximately 18 kg carcass weight). Groups of three adjacent chops from the mid-section of the loin were selected and treated as described for steak. Rolled shoulder roasts were treated as described for topside roasts.

Chicken

Twelve frozen chickens (No. 17; minimum weight 1.7 kg) were thawed in a chiller at 4 °C. The chickens were removed from their bags, weighed and divided into three groups of four. One group was studied fresh and the remaining two studied following cooking (one group roasted and one group microwaved).

Eight fresh chickens (No. 11; minimum weight 1.1 kg) were weighed and divided into two groups of four. One group was studied fresh, the other group was studied following barbecuing.

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Cooking methods for beef and lamb

Samples were not trimmed prior to cooking. Pan-frying was carried out in a non-stick frying pan heated on an electric hot plate. No additional fat was added. Grilling was carried out in an electric vertical griller. Roasting was carried out in a fan-forced electric oven, temperature controlled at 175 °C. The samples were cooked to an internal temperature of 70-75 °C (measured with an Ebro 'Tempo-Therm' temperature probe and referred to as 'medium done').

Cooking methods for chicken

Roasting was as described for lamb and beef, but to an internal temperature of 80 °C. Microwave cooking was carried out in a 650 W microwave oven set on medium, the chickens being cooked to an internal temperature of 80 °C. Barbecued chickens were cooked in a commercial rotisserie.

Methods of analysis

Cooked samples were weighed before and after cooking.

All of the raw and cooked beef and lamb samples were divided into separate components for analysis: trim (subcutaneous fat with traces of muscle); lean (muscle with its intramuscular and intermuscular fat); bone; and tail (lamb chops only; some muscle and subcutaneous fat). The water and fat content of the various components, excluding bone, was determined by the Soxhlet method described by Thornton *et al.* (1981).

All of the fresh and cooked chickens were divided into halves, giving a total of eight sides representative of each treatment. Each side was then separated into drumstick, thigh, breast and remainder portions. Each portion was separated into skin, meat and bone components, all of which were weighed. All skin and meat components were analysed for their water and fat content by the Soxhlet method described by Thornton *et al.* (1981).

The fat content of portions and samples were calculated using the weight and analytical data of the various components. Total cooking losses were calculated from fresh and cooked weights by subtraction. The contributions of water, fat and bone losses to the total cooking loss were similarly calculated from the weight and analytical data of all components.

Statistical methods

Analysis of variance was applied to each component (lean, trim, skin and total) of each beef and lamb sample and each chicken portion (breast, drumstick, thigh and remainder). Least significant differences (LSD) were calculated from the error mean square of each analysis of variance.

Results and discussion

The fat content values obtained for beef, lamb and chicken are presented in Tables 1, 2 and 3 respectively. The losses associated with the cooking of all three meats are presented in Table 4, and the yields of cooked lean meat, as a percentage of the total fresh cuts, are presented in Table 5.

In these studies, statistical comparisons have been made only between the raw and cooked states within a cut or portion, since between carcass variance could not be estimated. This highlights a problem in studies such as this, since the same piece of meat cannot be analysed both raw and cooked. In an attempt to reduce variance, adjacent slices taken from the mid-section of the same cut were studied. However, dividing the large cuts (i.e. the topside and rolled shoulder roasts) into halves resulted in variable data and large LSD values (see Tables 1 and 2). Because of this problem, and to clearly illustrate the variability encountered, all of the compositional data have been presented as means and ranges. In other studies (Renk, Kauffman and Schaefer 1985), slices have been taken from the same position on the left and right sides of the same animal, in an effort to reduce the variance in raw versus cooked meat studies, but even this approach has its limitations.

The content of fat in meat is largely a function of the amounts of subcutaneous, intermuscular and intramuscular adipose tissue associated with the muscle. Most of the fat is in the subcutaneous adipose tissue (or selvedge fat). This is illustrated by the fact that the fat content of complete cuts of beef and lamb was three to four times as much as that of the lean, which contained only inter and intramuscular adipose tissue (see Tables 1 and 2). The higher levels of fat in the complete T-bone and rump cuts when compared to those of blade and topside is indicative of a greater depth of selvedge fat over the loin and rump areas of the carcass. This selvedge fat can be readily identified and removed from mosts primal cuts of beef and lamb. It is also clear that the lean of rump and T-bone steak contains more fat than that of blade or topside (see Table 1). These differences largely reflect the varying amounts of intramuscular adipose tissue associated with the muscles of these cuts. The factors which control the differential appearance, development and growth of intramuscular adipocytes remain to be elucidated (Thornton and Tume 1987).

TABLE 1
Percentage fat in boneless beef cuts (g/100g)

	T-Bone			Rump			Blade			Topside		
	Lean	Trim	Total	Lean	Trim	Total	Lean	Trim	Total	Lean	Trim	Total
Raw[a]	3.7	45.2	16.4	3.4	64.1	15.2	2.2	44.3	9.2	2.0	57.0	12.3
Range	2.3/5.1	37.4/61.0	12.6/20.7	1.4/5.7	53.7/70.5	11.9/18.7	0.5/3.5	38.0/55.0	6.1/12.9	0.7/3.0	33.9/72.7	7.6/21.4
Grilled[a]	4.0	36.4	13.3	5.2	64.0	15.2	3.7	40.3	8.0			
Range	2.1/5.9	22.5/49.5	7.6/17.9	3.0/6.5	56.0/73.0	11.4/18.4	0.6/8.9	24.1/63.9	4.2/10.7	—	—	—
Pan-fried[a]	6.3	42.5	17.9	4.9	61.6	18.7	3.2	44.6	13.1			
Range	3.9/8.4	34.5/49.7	11.8/22.5	3.0/6.7	52.6/66.4	9.7/21.5	0.9/5.1	35.7/62.1	6.5/19.7	—	—	—
Roasted[a]										3.4	40.2	7.4
Range	—	—	—	—	—	—	—	—	—	1.3/6.1	21.1/71.4	4.6/14.9
LSD	0.96	7.40	1.89	1.13	4.6	3.58	1.89	12.26	3.36	2.45	28.3	8.87

Lean = Meat free of trim
Trim = Subcutaneous fat and associated connective tissue and some lean
Total = Entire boneless meat inclusive of trim
[a]Values represent means (n = 8)
LSD = Least significant differences between means of the same component with different cooking methods ($p = 0.05$)

TABLE 2
Percentage fat in boneless lamb cuts (g/100g)

	Large loin chops				Small loin chops				Rolled Shoulder
	Lean	Trim	Tail	Total	Lean	Trim	Tail	Total	Total
Raw[a]	7.9	77.0	24.9	37.4	5.3	74.9	30.8	37.2	22.0
Range	4.2/10.2	73.9/82.9	14.7/34.9	26.3/47.2	4.1/7.1	68.9/80.6	8.5/41.6	29.6/43.2	16.3/28.1
Grilled[a]	10.4	71.8	25.4	32.7	7.9	68.7	24.8	30.0	
Range	6.0/13.5	58.9/79.3	12.5/31.7	21.0/37.3	5.4/12.9	61.5/75.5	14.2/33.5	25.0/40.2	—
Pan-fried[a]	8.0	70.6	22.1	38.1	8.0	66.0	25.9	33.7	
Range	3.6/12.6	64.9/74.8	12.1/38.5	28.4/45.0	5.7/12.7	55.7/71.1	14.2/35.8	25.2/48.9	—
Roasted[a]									26.8
Range	—	—	—	—	—	—	—	—	23.5/31.2
LSD	3.28	6.13	10.43	5.76	2.40	5.64	5.87	4.60	4.21

Lean = Meat free of trim
Trim = Subcutaneous fat and associated connective tissue and some lean
Tail = Subcutaneous fat and some lean
Total = Entire boneless meat inclusive of trim and tail
[a]Values represent means (n = 8).
LSD = *Least significant differences between means of the same component with different cooking methods* (p = 0.05)

TABLE 3

Percentage fat in boneless chicken portions (g/100g)

	Drumstick			Breast			Thigh			Remainder		
	Lean	Skin	Total	Lean	Skin	Total	Lean	Skin	Total	Lean	Skin	Total
Raw[ac]	5.6	29.2	9.0	2.5	42.4	10.7	11.2	47.9	23.1	10.6	40.7	27.1
Range	2.9/8.0	17.3/41.3	5.4/13.4	2.0/3.0	36.2/48.2	9.1/14.1	6.7/15.9	38.8/56.1	17.8/31.9	5.1/16.2	28.7/50.7	15.5/35.8
Barbecued[ac]	5.6	23.2	7.8	1.6	37.3	6.1	11.4	34.4	16.6	10.5	36.9	17.8
Range	3.0/9.7	16.8/28.2	4.2/11.6	0.8/2.3	30.7/41.5	4.4/7.0	8.6/15.0	20.8/43.8	13.2/21.6	7.9/12.3	30.0/47.7	15.0/22.8
Raw[bc]	5.2	28.4	8.9	2.7	46.7	9.2	11.8	48.3	21.9	8.8	42.1	26.8
Range	2.7/8.4	14.1/34.8	4.4/14.3	2.4/3.2	38.5/53.3	7.1/11.7	8.7/15.8	42.8/53.2	15.9/28.5	5.4/11.5	31.1/56.2	13.3/42.3
Micro-waved[bc]	4.6	38.8	9.4	2.1	38.3	5.4	10.4	41.9	17.9	15.5	36.7	20.6
Range	3.7/6.3	32.3/44.3	6.8/12.7	1.0/4.3	30.3/44.7	3.1/10.3	8.1/15.4	34.0/50.4	13.2/21.6	7.9/22.7	34.1/40.5	12.9/24.7
Roasted[bc]	4.8	33.3	9.1	1.4	34.7	5.2	10.1	42.1	16.6	11.2	33.6	18.6
Range	3.2/6.2	20.6/39.7	6.2/12.4	0.5/1.9	31.5/40.4	3.3/7.1	7.3/14.4	37.0/48.4	14.7/21.4	4.0/25.2	26.4/39.5	15.5/27.0
LSD	1.62	6.52	2.51	0.76	5.82	2.90	2.69	6.67	3.88	4.46	6.46	6.95

Lean = Meat free of skin

Total = Entire boneless portion inclusive of skin

[a] Chilled No. 11 chicken

[b] Frozen No. 17 chicken

[c] Values represent means (n = 8)

LSD = Least significant differences between means of the same component with different cooking methods (p = 0.05)

TABLE 4
Calculated mean cooking losses (g/100g of total fresh cut)

4a. *Beef*

	T-bone		Rump		Blade		Topside
	Grilled	Fried	Grilled	Fried	Grilled	Fried	Roasted
Water	22.0	18.4	32.5	27.5	27.9	28.9	26.0
Fat	5.8	2.6	5.9	1.9	3.6	0.4	7.7
Bone	4.1	4.8	—	—	—	—	—
Total	31.9	25.8	38.4	29.4	31.4	29.2	33.7
Range	24.9/45.7	17.4/33.0	30.6/45.7	24.2/34.9	26.4/37.5	23.6/33.9	29.1/37.9

4b. *Lamb*

	Large loin chops		Small loin chops		Rolled
	Grilled	Fried	Grilled	Fried	Shoulder Roasted
Water	21.8	16.8	15.0	13.5	29.8
Fat	18.6	11.2	16.0	11.6	4.5
Bone	1.1	0	3.9	2.5	—
Total	41.5	28.0	34.9	27.6	34.3
Range	35.0/46.7	17.9/35.6	30.3/46.4	21.4/36.5	31.2/39.5

4c. *Chicken*

	Frozen No. 17		Chilled No. 11
	Roasted	Microwaved	Barbecued
Water	8.1	8.9	20.4
Fat	6.6	5.5	8.1
Bone	2.2	2.2	9.0
Total	16.8	16.5	37.4
Range	14.0/19.9	13.6/20.3	35.3/39.6

Whole lamb loin chops contained large amounts of fat (>37%; see Table 2) which gives an indication of the amount of subcutaneous fat covering the 'eye muscle' and the amount of fat in the 'tails' of the chops. However the level of intramuscular fat in raw lean was considerably higher than we expected, based upon the results of previous carcass meat compositional studies on mature sheep (Thornton *et al.* 1979; Thornton *et al.* 1981). In the studies on mature sheep, intramuscular fat levels were of the order of 2–3%, compared with 5–8% in this study on lambs. We attribute this high level of intramuscular fat in lamb to the high dietary lipid intake of the suckling/grazing lamb (Thornton and Tume 1984).

The fat content of some portions of chicken relative to that of beef or lamb is clearly higher, even following removal of the skin, than is the much publicised perception of some groups (Stafford 1983; Diamond and Diamond 1985). This is presumably because the fat associated with chicken meat is more oily and not as visible as that associated with red meats, i.e. beef and sheep meat. Furthermore, the cold fat of chicken meat and skin is probably not as unpleasant to the palate of most consumers as is the cold fat of beef or sheep meat. The fat content values found for chicken in this study are similar to those reported by others (Parsons 1987; Hutchinson *et al.* 1987). Only the breast meat lean could be described as being very low in fat, i.e. less than 3%. Total fat losses during roasting or microwave cooking of chicken amounted to about one-third of the total cooking losses (see Table 4).

Barbecuing of chickens resulted in large losses of water, fat and bone weight, totalling 37%. However it cannot be concluded from this study that barbecuing resulted in a doubling of the cooking losses suffered during roasting or microwaving (16–17%) as the barbecued chickens were chilled and much smaller than the frozen chickens which were roasted or microwaved.

Cooking losses of both steak and lamb chops were higher when grilled than pan-fried (see Table 4), and meat which was pan-fried had a higher fat content than grilled meat (see Tables 1 and 2). Although the water loss for steak during cooking was six to seven times

greater than the fat loss, the fat loss from lamb chops during cooking was almost as much as the water loss, irrespective of the cooking method.

The yield of cooked lean meat (see Table 5) is determined by the bone and fat selvedge content of the cut and the cooking losses suffered by the cut. Cuts containing bone, e.g. lamb chops, T-bone and chicken, have lower yields of cooked lean than cuts with no bone, e.g. rump, blade and topside. It is revealing to calculate the cost of cooked lean meat eaten (i.e. percentage yield of cooked lean (Table 5) x retail cost), as some cheaper cuts of meat are then found to be as costly as more expensive cuts, in terms of cooked lean yield.

TABLE 5
Mean percentage yield of cooked lean meat (g/100g of total fresh cut)

Cut	Cooking method	%
T-bone	Grilled	36.1
	Fried	38.6
Rump	Grilled	51.2
	Fried	53.6
Blade	Grilled	59.8
	Fried	53.6
Topside	Roasted	60.1
Lamb chops (large)	Grilled	23.6
	Fried	26.2
Lamb chops (small)	Grilled	23.4
	Fried	23.2
Chicken	Microwaved**	41.4
	Roasted**	39.3
	Barbecued*	33.5

** = No. 17 chicken
* = No. 11 chicken

Conclusions

The broad ranking order for the fat content of the lean cooked meats in this study was: chicken breast < beef = chicken drumstick < lamb loin chops < chicken thigh < chicken remainder.

Although higher in fat content than the lean of cooked chicken breast (1.4 to 2.1%), the lean of cooked beef has a similar fat content (3.2 to 6.3%) to cooked chicken breast inclusive of skin (5.2 to 6.1%), and both are lower than the lean of cooked lamb chops (7.9 to 10.4%), or cooked drumsticks inclusive of skin (7.8 to 9.4%). Whole lamb loin chops contained large amounts of fat (37%) and whole beef cuts contained 9–16% fat.

Dietary guidelines for Australians recommend that not more than 35% of energy intake should be derived from fat (English 1983). Using energy values of 17 kJ/g for protein, 16 kJ/g for carbohydrate and 37 kJ/g for fat, it can be calculated that approximately 15% of fat in the diet will supply 35% of the energy intake. The lean of meats studied here (beef, lamb and chicken) did not provide this level of dietary fat.

Thus our conclusions are not dissimilar to those we have previously reported (Thornton and Larsen 1985). Firstly, fatty meat is an energy dense food. However, at least for some traditional cuts of lean meat, most of the fat is clearly visible and easily separable, which allows the consumer to select, or adjust, the fat content of the meat actually cooked and/or eaten. Furthermore, the use of certain cooking procedures, particularly grilling, result in the loss of considerable amounts of fat. Secondly, from a nutritional viewpoint, any lean meat, be it from cattle, sheep, pigs or poultry is 'regarded as a good source of energy and of protein (as it contains a well-balanced complement of the essential amino-acids) and, to a lesser extent, of minerals (iron (readily available), potassium, zinc and copper), B vitamins (thiamin B1, riboflavin B2, niacin and B12) and essential fatty acids. Furthermore, meat is a highly acceptable food in the general community; it is readily digestible, yet gives satiety, and people do not tire of eating it. Thus lean meat can be described as a highly desirable, nutritious food' (Thornton and Larsen 1985).

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The influence of gender and social class on the nutrient contribution of meat and meat products to the diet of a group of urban Australians

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Introduction

Despite an increasing awareness of the role that nutrition plays in the aetiology of chronic diseases such as coronary heart disease, certain cancers, gallstones, renal stones and diabetes (Better Health Commission 1987), there is still a paucity of data concerning the nutritional intake and food consumption patterns of Australians. Dietary intervention strategies to reduce the chronic disease risk profile can only be effective if based on a sound understanding of the patterns of intake and their socio-economic, psychological and cultural determinants.

One aspect of the diet that has received much scientific and media attention is the meat and meat products group and its role in a balanced diet. The apparent consumption figures for Australia (Australian Bureau of Statistics 1986) shows over a twenty per cent drop in consumption from the late 1950s until the early 1980s in total meat, 'carcass' meat and canned meats consumption (excluding poultry). There was also a 10% drop in offal consumption but a doubling of consumption of cured meats which still however account for only some 6-7% of total meat consumption. Since 1980, beef consumption has fallen by a further 10% but pork and sheep meats have increased by some 13-15%.

This changing pattern of meat consumption may be due to a variety of socio-economic factors but adverse publicity relating to the level of fat and, in the case of some meat products and dishes, the energy density and high salt content has undoubtedly contributed to the decline.

The reduction in consumption levels and ongoing concerns with product quality have led to increased research and industry efforts to produce leaner cuts of meat, to produce meat products with reduced fat and salt levels and to develop marketing strategies that encourage more appropriate food preparation techniques relevant both to commercial outlets and individual households.

Despite concerns about the fat and particularly saturated fat contributed by these products, meats and meat products are valuable food sources for a range of nutrients many of which are hard to replace from other components of the food supply. The data presented here outlines the contribution of meats and meat products to the nutrient intake

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of urban Australians in relation to gender and social class.

Methods

Subjects

The subjects whose dietary patterns are described in this paper were taking part in a large study of the socio-economic and cultural determinants of health in children and their families. The subjects were originally identified as the parents of all children born at the largest public maternity hospital in Adelaide over a seven month period during 1975-76 when the infants were screened as part of a blood lipid study.

Seven hundred families were recontacted in 1985 and asked to take part in the study. They were asked to complete detailed questionnaires relating to dietary intakes of family members, dietary habits, and socio-economic and attitudinal variables in relation to health and nutrition.

Complete data sets were obtained from four hundred and forty women and three hundred and ninety-seven men, ninety per cent of the final sample being married couples. The mean age of the subjects was 34 with a range from 25 to 52 years. The subjects were divided into four socio-economic categories based on occupational status according to the job prestige ranking scale of Daniel (1983). Because of the difficulties involved in classifying 'home duties' on the occupational scale, the women's ranking was based on the occupation of their spouse.

Occupational category 1 (Daniel's scale 1.2-3.4) included professional and top managerial occupations such as judges, magistrates and lawyers, medical specialists and general practitioners, tertiary education lecturers, professional scientists and engineers, senior armed and civil service personnel and managers of large companies.

Category 2 (Daniel's 3.5-4.0) included semi-professional and middle management groups such as primary and secondary school teachers, small businessmen, technical and bank officers and professional health care and social workers.

Category 3 (Daniel's 4.1-4.9) included skilled tradesmen, service staff and clerical staff such as electricians, computer technicians, small business managers, small farmers, craftsmen, firemen and policemen.

Category 4 (Daniel's 5.0-6.7) included semi-skilled and unskilled manual, clerical and sales staff such as salesmen, junior clerks, drivers, building labourers, factory workers and farm labourers.

Where the job description given was too vague, or in the case of students, pensioners or unemployed persons (< 4% subjects in all) that subject was not included in the analysis.

Dietary intake instrument

Information concerning dietary intake was obtained with a self-administered questionnaire using a quantitative frequency format. Different versions of this questionnaire have been used extensively in studies of dietary intake in Australian populations and have been shown to have high repeatability (Baghurst and Record, 1983, 1984). The full version of the questionnaire contained a list of over 170 items plus extensive additional qualitative and quantitative questions concerning food preparation and cooking and eating habits with particular reference to their effects on fat, sugar, salt and vitamin content of food. There was also a range of questions concerning the use of specific types of food covered by a general category in the main frequency list (e.g. types of bread; types of fat spread; types of breakfast cereal eaten etc). Where appropriate, information from these qualitative and quantitative questions was used to modify the analysis obtained from the main frequency grid.

Daily nutrient intake was calculated by computer using the formula

Nutrient intake per day	=	Frequency of use of dietary item	x	respective serve size	x	relevant nutrient content/ 100 gm

Standard serving sizes were determined using a combination of data derived from weighed diet diaries collected from a variety of subpopulations during our own studies, together with standard serve sizes as given by Thomas and Corden (1970) for individual items such as eggs, apples, etc. The standard serve sizes were listed against each item and where the individual's usual serve size differed from the standard, he or she was asked to note this in a comment column and an adjustment was made. This comment column was also used to indicate seasonal usage of foods. Nutrient content per unit weight was calculated from the values given for each item in the standard food table adjusted, where applicable, for changes made during food preparation to fat, sugar or vitamin content according to answers to questions concerning food preparation and cooking practices.

The nutrient data base used in our analysis system was derived from the revised McCance and Widdowson (British) food tables of 1978. These were used in preference to the current Australian tables of food composition for several reasons. Firstly, the data in the McCance and Widdowson tables were

obtained in a more rigorous and consistent fashion than those given in the Australian tables, which contain information from a variety of sources, many of them also overseas. The McCance and Widdowson tables also contain a much wider range of foods and nutrients (including fibre and types of fat and carbohydrate) not available in the Australian tables. There are nearly 1000 food items listed in the data base although some of these are general categories not used for analysis purposes. Where specifically Australian data were available, and where they deviated substantially from the British tables, the nutrient content of the food items was adjusted to the value relevant to Australia.

The 32 meat items listed individually on the questionnaire were: steak (grilled); steak (fried); pork chops (grilled); pork chops (fried); lamb chops (grilled); lamb chops (fried); roast pork; roast beef or veal; roast lamb; mince meat (eaten as such); spicy mince; pork sausages (grilled); pork sausages (fried); beef sausages (grilled); beef sausages (fried); frankfurters/saveloys etc; liver; kidney; bacon; ham; fritz/devon etc; salami/mettwurst etc; crumbed veal/schnitzels; mince meat dishes (eg moussaka, shepherd's pie etc); stews/casseroles; curry/goulash etc; chinese meat and vegetable dishes; meat pie (shop or commercial); meat pie (home made); hamburgers with bun; hamburger patty; sausage roll.

The questionnaires together with full instructions were posted in a return paid envelope to participants for completion in their own homes where it was possible for them to check serve sizes and brands of food. On return, they were checked for omissions and errors by an experienced research officer before analysis.

Data relating to occupational status and a range of other demographic and attitudinal variables was collected in the same manner at the same time.

TABLE 1
Mean daily intakes in subjects by gender and occupational status

	Males			Females		
	Total	Upper	Lower	Total	Upper	Lower
Nutrient	n = 397	n = 92	n = 85	n = 440	n = 83	n = 82
Energy (MJ)	10.75	9.25	12.27	8.20	7.48	8.41
Protein (g)	103	90	117	86	80	88
Total Carbohydrate (g)	283	247	315	221	199	225
— Complex	136	116	156	101	93	100
— Simple	147	131	159	120	106	125
Total Fat (g)	112	94	132	85	75	89
— Saturated fat	46	39	54	35	31	37
— Monounsaturated fat	42	34	50	31	26	33
— Polyunsaturated fat	24	21	28	19	18	19
Cholesterol (mg)	345	267	422	273	237	294
Sodium (mg)	3609	2947	4222	2771	2474	2873
Potassium (mg)	4435	4386	4738	4143	3846	4110
Iron (mg)	16.2	15.4	17.4	13.8	13.6	13.9
Zinc (mg)	14.2	12.6	15.8	12.0	11.1	12.0
Copper (mg)	2.4	2.2	2.7	2.1	1.9	2.1
Thiamine (mg)	1.5	1.4	1.6	1.3	1.2	1.2
Riboflavin (mg)	2.5	2.3	2.7	2.1	2.0	2.1
Vitamin B_6 (mg)	1.8	1.7	1.9	1.6	1.5	1.6
Vitamin B_{12} (μg)	6.7	5.8	8.5	6.1	4.8	7.2
% energy as —						
Protein	16.3	16.5	16.2	17.8	18.1	17.8
Total Carbohydrate	42.1	42.7	41.1	43.1	42.6	42.8
— Complex	20.2	20.1	20.3	19.7	19.9	19.0
— Simple	21.9	22.7	20.7	23.4	22.7	23.8
Total fat	38.5	37.6	39.8	38.3	37.1	39.2
— Saturated fat	15.8	15.6	16.3	15.7	15.3	16.3
— Monounsaturated fat	14.4	13.6	15.1	14.0	12.9	14.5
— Polyunsaturated fat	8.3	8.4	8.4	8.6	8.9	8.4

Results and Discussion

Dietary intake

Table 1 shows the nutrient intake of the subjects involved in the study and the effect of social status on intake. The results for the upper and lower occupational groups only are shown, those for occupational groups 2 and 3 being intermediate throughout the study.

The mean intakes for major nutrients and their percentage contribution to total energy intake were similar to those previously reported for randomly selected South Australian populations (Baghurst and Record 1983). Approximately 16% of energy was derived from protein, 42% from carbohydrate and 38% from fat.

When the nutrient intakes of the upper social category (occupational category 1) was compared to that of the lowest group (occupational category 4) there were some striking differences. Total energy intake was some 15% higher in lower class males and 12% higher in lower class females than in the respective upper class groups. Absolute protein intake was lower in the top social classes but percentage contribution of protein to total energy was marginally higher. Both simple and complex carbohydrate intake was substantially lower in the top groups but percentage contribution to energy was similar in both groups.

Total fat intake and the daily intake of saturated, monounsaturated and polyunsaturated fats was also lower in the top social groups, with the exception of polyunsaturates in women which were similar in both groups. The fat density of the diet (ie gms fat per MJ energy) was also lower in the top groups as was the density of saturated and monounsaturated fats. The density of polyunsaturated fat was however similar in the two groups of men and somewhat higher in the diets of the top strata of women.

As might be expected, the absolute intake of energy and all macronutrients was lower in women than men. The nutrient density of proteins, fats and carbohydrates was however similar to that in men.

Absolute cholesterol intake in men was 60% higher in the lower status group and in women it was 25% higher. The mean cholesterol density was similar in males and females (32 mg/MJ energy — males vs 33 mg/MJ energy — females) but the lower status males had densities 17% greater than their upper status counterparts and the lower status women had levels 9% above those of the upper status women.

Sodium intakes were higher in males than females but the sodium density of the diet was similar (approximately 340 mg sodium/MJ energy). The upper occupational groups had lower absolute sodium intakes and sodium densities (318 mg sodium/MJ vs 344 mg/MJ for men; 331 mg sodium/MJ vs 342 mg/MJ for women).

Absolute intakes for most of the micronutrients was lower in females than males and lower in the upper occupational categories. However, the densities of micronutrients were higher for females and for the upper occupational groups indicating qualitative as well as quantitative differences in diets according to gender and occupational status.

The contribution of meats

Tables 2 and 3 show the percentage contribution of meats, meat products and composite dishes containing meats to overall nutrient intake. It should be noted that for both the products and the composites, it is the contribution of the total product or item that has been documented, not merely that of the meat component.

Meat, meat products and composite dishes contributed 19% of total energy, over 60% of the vitamin B_{12}, over 40% of zinc, over 30% of the protein and monounsaturated fat, over 20% of the iron, copper, riboflavin, and vitamin B_6 and 12-15% of the polyunsaturated fat, potassium and thiamine. However they also contributed to over 30% of the cholesterol and sodium and over 20% of total and saturated fat, a disproportionate amount of fat and sodium being contributed by the products and composite dishes. The 'meat' category itself contributed only 7.5% of the energy in the diet but over 20% of the protein. It accounted for only 10-12% of total and saturated fat and only 4% of sodium. This category was the predominant contributor to iron, zinc, copper, riboflavin, vitamin B_6 and vitamin B_{12}. It did however contribute to 23% of total cholesterol intake. The meat products were particularly high contributors to sodium (17%) and to a lesser degree to total saturated and monounsaturated fats. Composite meat dishes also contributed significantly to sodium intake (10.8%).

There were some marginal differences between men and women in the percentage energy and nutrients provided by the meat, meat products and composites with a slightly higher contribution of these items in males to total protein and fats in the diet but overall, the pattern of contribution to energy and nutrient intake by the meat group was similar between the sexes. There were however substantial differences between the occupational

TABLE 2
% Contribution of meats, meat products and composite foods to major nutrient intake in relation to occupational status

Nutrient		Total sample (n = 837)	Males		Females	
			Upper n = 92	Lower n = 85	Upper n = 83	Lower n = 82
Energy	— Total	18.6	16.5	21.0	15.2	19.3
	— Meats#	7.5	6.8	8.7	6.5	7.0
	— Products*	4.8	3.5	6.0	3.1	6.1
	— Composites†	6.3	6.2	6.3	5.6	6.2
Protein	— Total	36.0	33.1	39.2	30.6	37.3
	— Meats	20.3	18.3	22.7	17.1	21.6
	— Products	6.9	5.3	8.6	4.5	6.5
	— Composites	8.8	9.5	7.9	9.0	9.2
Fat	— Total	27.0	24.1	31.1	20.1	27.1
	— Meats	10.5	8.8	11.9	7.4	12.8
	— Products	8.3	6.2	10.7	5.3	7.4
	— Composites	8.2	9.1	8.5	7.2	6.9
Saturated fat	— Total	27.9	24.3	33.1	21.0	27.0
	— Meats	11.0	9.1	13.1	8.3	13.6
	— Products	8.8	6.6	11.4	5.9	6.8
	— Composites	8.1	8.6	8.6	6.8	6.6
Monounsaturated fat	— Total	34.7	29.3	38.8	27.4	35.3
	— Meats	12.7	10.4	14.4	10.5	15.3
	— Products	11.8	7.5	14.9	8.0	11.3
	— Composites	10.2	11.4	9.5	8.9	8.7
Polyunsaturated fat	— Total	15.1	13.6	18.6	11.7	18.7
	— Meats	6.6	4.6	9.9	3.7	10.7
	— Products	2.8	2.0	3.2	1.8	2.6
	— Composites	5.7	7.0	5.5	6.2	5.4
Cholesterol	— Total	37.0	35.2	37.7	33.8	37.9
	— Meats	23.0	22.4	23.1	20.9	23.2
	— Products	6.2	5.2	8.3	4.3	5.8
	— Composites	7.8	7.6	6.3	8.6	8.0

Foods included:
meats — steaks, chops, roast meats, minced meats and patties, kidney, liver, etc.
* products — sausages, frankfurters, saveloys, bacon, ham, fritz, devon, salami, mettwurst, etc.
† composites — crumbed veal/schnitzel, moussaka, shepherd's pie, stews, casseroles, chinese meat dishes, curries, goulash, meat pies, sausage rolls, hamburgers (with bun), etc.

categories. For both men and women there was a substantially higher contribution of meat to percentage energy, protein, fats and many of the micronutrients in the lower occupational groups. The most striking difference being the relative contribution of meat products to energy and nutrient intake. This category provided twice the percentage energy in the lower occupational category and also made a substantially higher contribution to percentage protein, fats and micronutrients. The percentage energy contributed by meat was approximately one-third higher in the lower occupational category for men but only 8% higher for women. The contribution of composite dishes was similar in the two occupational groups for men and some 11% higher in lower occupational status women.

The consumption of individual meat items

Table 4 shows the contribution of some of the individual food items to total percentage energy intake as well as the mean intake in g/day for the various sex-occupational status groups.

For the men, meat pies bought in shops or made commercially were the most prominent single item for both occupational categories however they contributed substantially more to the overall diet of the lower social group with a mean daily consumption of some 33 g/day in comparison to 17 g/day in the upper group. If

TABLE 3
% Contribution of meats, meat products and composite foods to the intake of certain minerals and vitamins

Nutrient		Total sample (n = 704)	Males		Females	
			Upper	Lower	Upper	Lower
Sodium†	— Total	31.9	28.3	33.1	26.5	33.6
	— Meats	4.1	3.5	4.2	3.4	4.4
	— Products	17.0	13.2	17.4	11.7	17.4
	— Composites	10.8	11.8	11.5	11.4	11.7
Potassium	— Total	12.5	11.7	13.9	11.0	12.6
	— Meats	6.0	5.0	7.3	4.8	5.7
	— Products	1.7	1.4	2.2	1.2	1.7
	— Composites	4.8	5.3	4.4	5.0	5.2
Iron	— Total	26.2	23.6	30.0	22.6	27.4
	— Meats	15.2	13.1	18.6	13.2	16.7
	— Products	3.6	2.6	4.6	2.3	3.5
	— Composites	7.4	7.9	6.8	7.1	7.2
Zinc	— Total	42.6	39.5	46.1	35.5	44.3
	— Meats	28.6	26.9	31.3	23.4	30.5
	— Products	6.2	4.6	7.5	4.1	6.1
	— Composites	7.8	8.0	7.3	8.0	7.7
Copper	— Total	22.9	18.5	24.8	19.7	26.9
	— Meats	12.7	10.4	14.8	12.1	18.1
	— Products	5.8	3.6	6.0	3.1	4.7
	— Composites	4.4	4.5	4.0	4.5	4.1
Thiamine	— Total	15.0	11.7	18.6	10.6	15.6
	— Meats	6.2	4.5	6.6	4.3	6.1
	— Products	5.5	3.8	8.0	3.6	5.9
	— Composites	3.3	3.4	4.0	2.7	3.6
Riboflavin	— Total	20.3	17.1	22.7	16.6	24.4
	— Meats	13.7	11.4	15.3	10.8	17.5
	— Products	3.1	2.3	4.2	2.3	2.9
	— Composites	3.5	3.4	3.2	3.5	4.0
Vitamin B_6	— Total	23.4	21.9	27.9	20.4	23.7
	— Meats	12.6	11.1	15.0	10.4	12.7
	— Products	3.3	2.7	5.9	2.2	2.9
	— Composites	7.5	8.1	7.0	7.8	8.1
Vitamin B_{12}	— Total	66.8	60.9	65.5	65.2	72.9
	— Meats	53.9	47.9	53.2	51.6	61.9
	— Products	4.1	3.4	5.1	3.0	3.4
	— Composites	8.8	9.6	7.2	10.6	7.6

† Sodium in the food supply — naturally occurring or added in commercial preparation — does not include salt added at the table or in home cooking.

grilled and fried lamb chops were considered together they contributed a marginally higher percentage energy to the diet than meat pies. There was an average consumption of 18 g/day for grilled and 8 g/day for fried chops, but in the lower group each type contributed equally (16 g/day). The upper social group had an identical intake of grilled chop (16 g/day) but only consumed 4 g/day fried chop. The lower group also had a major contribution from fried steak (13 g/day). There was a similar g/day intake of grilled beef sausages, stews and casseroles, hamburgers, sausage rolls, spicy mince, and roast lamb but a higher g/day consumption in the lower group of salami/mettwurst, plain minced meat, grilled steak, fritz/devon and bacon. The upper social group had a higher consumption of schnitzel, minced meat dishes and chinese meat dishes.

In the women, lamb chops were the predominant meat source. On average, they consumed 16 g/day grilled chops and an additional 6 g/day as fried chops. Each occupational category had almost identical

intakes for grilled lamb chops (15 g each) but the lower social group again had a higher intake of fried chops (12 g/day vs 2 g/day). Composite dishes such as stews, casseroles and minced meat dishes were consumed in similar amounts by both social groups, the figures for stews/casseroles being 17 g upper, 21 g lower, and for minced meat dishes, 8 g vs 6 g/day. Takeaway items such as meat pies, hamburgers and sausage rolls were not dominant items for women with an average intake of only 6 g/day for meat pies (4 g upper; 7 g lower), 5 g/day for hamburgers (5 g vs 4 g) and sausage rolls averaging only 1 g/day in each group.

The consumption of fried items was again substantially higher in the lower social category for women with intakes of 12 g/day fried lamb chops in the lower occupational group compared to 2 g/day for the upper group, 6 g for fried steak compared to 1 g and 5 g for fried beef sausage compared to 0.5 g in the upper group.

The intake of grilled lamb chop, grilled steak, spicy mince, minced meat dishes, grilled beef sausage, hamburger and salami/mettwurst was similar in the two occupational groups for women but there was a higher intake of roast lamb, chinese dishes and curry/goulash in the upper group and a lower intake of minced meat, schnitzel, meat pies and fritz/devon as well as the fried items.

Comparing men and women, there was a

TABLE 4
Major contributors amongst meats, meat products and composite dishes to total energy intakes

Males

All Subjects			Upper Social Class			Lower Social Class		
Item	% energy	Av. g/day	Item	% energy	Av. g/day	Item	% energy	Av. g/day
Meat pie (shop)	2.19	23	Meat pie (shop)	1.82	17	Meat pie (shop)	2.70	33
Salami/Mettwurst etc.	1.49	8	Beef sausage (grilled)	0.97	9	Lamb chop (fried)	2.47	16
Lamb chop (fried)	1.37	8	Hamburger with bun	0.97	8	Salami/Mettwurst etc.	1.90	11
Hamburger with bun	1.01	9	Lamb chop (grilled)	0.89	16	Minced meat	1.14	15
Steak (grilled)	0.99	15	Lamb chop (fried)	0.88	4	Hamburger with bun	1.02	11
Minced meat	0.91	10	Salami/Mettwurst etc.	0.83	4	Steak (grilled)	1.01	18
Beef sausage (grilled)	0.90	9	Stew/casserole	0.82	16	Beef sausage (grilled)	0.92	10
Lamb chop (grilled)	0.86	18	Steak (grilled)	0.81	11	Steak (fried)	0.82	13
Sausage roll	0.79	4	Sausage roll	0.72	4	Fritz/devon etc.	0.71	7
Fritz/devon etc.	0.79	7	Spicy mince	0.70	7	Stew/casserole	0.67	17
Stew/casserole	0.72	16	Minced meat	0.70	7	Lamb chop (grilled)	0.66	16
Steak (fried)	0.65	9	Schnitzel	0.66	7	Bacon (grilled)	0.65	6
Spicy mince	0.62	7	Roast lamb	0.59	7	Sausage roll	0.62	4
Roast lamb	0.58	8	Minced meat dishes	0.57	7	Spicy mince	0.57	7
Bacon (grilled)	0.58	5	Chinese meat dishes	0.57	14	Roast lamb	0.55	8

Females

All Subjects			Upper Social Class			Lower Social Class		
Item	% energy	Av. g/day	Item	% energy	Av. g/day	Item	% energy	Av. g/day
Lamb chop (fried)	1.26	6	Stew/casserole	1.09	17	Lamb chop (fried)	2.53	12
Minced meat dishes	1.05	11	Lamb chop (grilled)	1.02	15	Stew/casserole	1.23	21
Lamb chop (grilled)	1.02	16	Steak (grilled)	0.94	10	Minced meat	1.02	9
Stew/casserole	1.00	17	Spicy mince	0.92	7	Beef sausage (grilled)	0.97	7
Steak (grilled)	0.94	11	Minced meat dishes	0.85	8	Steak (grilled)	0.97	12
Minced meat	0.93	8	Beef sausage (grilled)	0.76	5	Spicy mince	0.97	9
Spicy mince	0.90	8	Schnitzel	0.75	6	Lamb chop (grilled)	0.90	15
Beef sausage (grilled)	0.88	6	Hamburger with bun	0.72	5	Schnitzel	0.88	10
Schnitzel	0.81	7	Salami/mettwurst etc.	0.70	3	Salami/mettwurst etc.	0.87	4
Meat pie (shop)	0.77	6	Roast lamb	0.60	6	Meat pie (shop)	0.85	7
Salami/mettwurst etc.	0.76	3	Lamb chop (fried)	0.58	2	Fritz/devon etc.	0.82	5
Hamburger with bun	0.71	5	Chinese meat dishes	0.57	11	Mince meat dishes	0.71	7
Roast lamb	0.65	7	Meat pie (shop)	0.55	4	Steak (fried)	0.61	6
Fritz/devon etc.	0.58	4	Curry/goulash	0.55	6	Beef sausage (fried)	0.61	5
Hamburger pattie	0.52	4	Minced meat	0.50	4	Hamburger with bun	0.58	4

four fold higher intake of meat pies and sausage rolls, two fold higher intakes of fritz/devon, steak, hamburgers, bacon and salami/mettwurst and a fifty per cent higher intake of beef sausages in the men. Intakes of lamb chops, minced meat, stews/casseroles, spicy mince and roast lamb were similar but women consumed more minced meat dishes and schnitzel.

Overall, the results show that meat cuts *per se* are a major supplier of protein and micronutrients in the diet of urban Australians providing only 7.5% of the energy and 10-12% of the fat. They do however contribute substantially to cholesterol intake. On the basis of their contribution to protein and micronutrient intake, the meat products and dishes, however, provide disproportionately high amounts of sodium, fat and energy. There are striking social class and sex differences both in the amounts of meats, meat products and dishes consumed, in the preferred dishes and in cooking methods. The higher level of fried meat items eaten by the lower occupational groups and the higher intake of takeaway foods consumed by males indicates that the lower social class male may be a group at particular risk of nutritional imbalance.

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A note on the cholesterol content of beef rib steaks

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Consumers are becoming increasingly aware of the nutritional value of food, particularly in relation to its fatty acid composition and cholesterol content. Most in the community understand that high levels of cholesterol in the blood increase the risk of developing heart and arterial diseases. A decrease in cholesterol consumption is one means of reducing the risk of developing these diseases. Cholesterol is a fatty compound found in foods of animal origin. Meat, particularly beef, is one of the most acceptable and widely eaten foods in our community and has, at times, been questioned as a dietary component because of its cholesterol content.

Consumers often have misconceptions and are misinformed about aspects of nutrition. For example, one popular view was that cholesterol could be avoided in meat by selecting meat with no marbling (visible intramuscular fat) and by trimming separable fat (subcutaneous and intermuscular fat). Literature values for cholesterol content of uncooked beef *longissimus dorsi* muscle, the major muscle in rib or T-bone steaks, are typically between 55-65 mg/100 g meat. However, values ranging from 36 (Stromer *et al.* 1966) to 78 (Terrell *et al.* 1969) have been reported. This research note describes the role of visible fat as a contributing factor to the total cholesterol content of meat.

Thirteen thick rib steaks were purchased from a supermarket in Sydney. Purchases were made on four occasions and care was taken to ensure that each steak analysed was from a different animal. A thin 10 g slice was removed from the *longissimus dorsi* muscle of each steak to determine the percent muscle lipid using the extraction method of Bligh and Dyer (1959) and detailed by Hood and Allen (1971). This extracted lipid represents structural lipid associated with membranes and intramuscular adipose tissue lipid. The remainder of each steak was used to meticulously dissect out the intramuscular fat (marbling) contained within the *longissimus dorsi* muscle. Triplicate 0.5 g samples of intramuscular fat, subcutaneous fat and lipid extracted from each steak were accurately weighed into 50 ml culture tubes for cholesterol determination.

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A set of eight culture tubes containing increasing amounts of cholesterol was used as standards for each series of assays. Fifteen ml of 95% ethanol and 1.5 ml of 33% KOH were added to each standard tube and to each tube containing either intramuscular fat, subcutaneous fat or lipid from the *longissimus dorsi* muscle. The tubes were sealed and placed in a water bath at 60 °C for 20 minutes to complete saponification. After cooling, 30 ml of hexane and 10 ml of water were added and the tubes shaken for 1 minute. The upper hexane layer contains cholesterol, free from contaminating lipids. One ml aliquots of the upper layer were pipetted into duplicate tubes. The hexane was evaporated under nitrogen and 2 ml of O-phthaldehyde reagent (Rudel and Morris, 1973) added, the tubes mixed and 10 minutes later 1 ml of 18M H_2SO_4 added and immediately mixed. Cholesterol was quantified by measuring the absorbance at 550 nm, between 10 and 90 minutes after addition of H_2SO_4.

The average cholesterol content of *longissimus dorsi* muscle trimmed of subcutaneous fat was 55.7 ± 2.12 mg/100 g which is significantly lower than the values of either isolated intramuscular adipose tissue (97.3 ± 9.1 mg/100 g) or subcutaneous adipose tissue (94.1 ± 9.7 mg/100 g). Since isolated intramuscular adipose tissue contained more cholesterol than intact muscle, rib steaks with more extensive marbling would be expected to have more cholesterol per 100 g of meat. In this study, *longissimus dorsi* lipid content ranged from 2.4 to 7.7 percent and surprisingly, rib steaks with the least amount of intramuscular fat had slightly higher cholesterol contents. This is reflected in a relationship between percent intramuscular lipid (X) and *longissimus dorsi* cholesterol content (Y),

$$Y = 59.95 - 1.01X \quad (r = -0.73)$$

The above relationship is valid for *longissimus dorsi* intramuscular lipid contents between 2 and 8 percent. Similar regression equations have been obtained by Tu *et al.* (1967) and Rhee *et al.* (1982b).

The lipid contained within the *longissimus dorsi* muscle is derived from two sources; the functional lipids of muscle cell membranes and the intramuscular adipose tissue lipids. The functional lipid remains constant at approximately 1.5% of the *longissimus dorsi* muscle and the lipid content of intramuscular adipose tissue was approximately 60% in this study. These two factors have been used to calculate the weight of intramuscular adipose tissue in Table 1.

In the steaks analysed, the average lipid content was 4.21% and from data presented in Table 1, only 8% of the cholesterol present in an average rib steak is derived from marbling. Therefore, the contribution of marbling fat to meat cholesterol is not significant. In fact, the data in Table 1 suggest that lean meat contains slightly more cholesterol than well marbled meat. However, to reduce cholesterol and kilojoules, meat should be selected, or trimmed, to contain a minimal amount of subcutaneous (covering muscles) or intermuscular (between muscles) fat since adipose tissue contains approximately 70% more cholesterol than muscle on a weight basis. Meat should be consumed with minimal fat,

TABLE 1
The lipid and cholesterol content of beef rib steak

Sample	Muscle Lipid (%)	Intramuscular[a] Adipose Tissue g/100g Muscle	Cholesterol mg/100 g of Adipose Tissue		Cholesterol mg/g of Extracted Muscle Lipid
			Intramuscular	Subcutaneous	
1	2.43	1.55	99.2	75.2	24.42
2	2.61	1.85	105.4	82.7	22.74
3	2.77	2.12	81.5	89.5	21.26
4	3.06	2.60	82.9	89.3	18.50
5	3.50	3.33	95.2	96.0	15.75
6	3.60	3.50	109.3	84.3	14.94
7	3.63	3.55	99.6	91.3	14.99
8	4.03	4.22	111.5	106.9	13.52
9	4.18	4.47	96.0	106.6	13.32
10	4.71	5.35	85.7	96.6	11.58
11	6.08	7.63	100.9	99.7	9.00
12	6.42	8.20	104.0	109.0	8.49
13	7.72	10.36	94.2	96.4	6.80
Mean	4.21	4.52	97.3	94.1	15.02

[a]Intramuscular adipose tissue = (muscle lipid — 1.5)/0.6

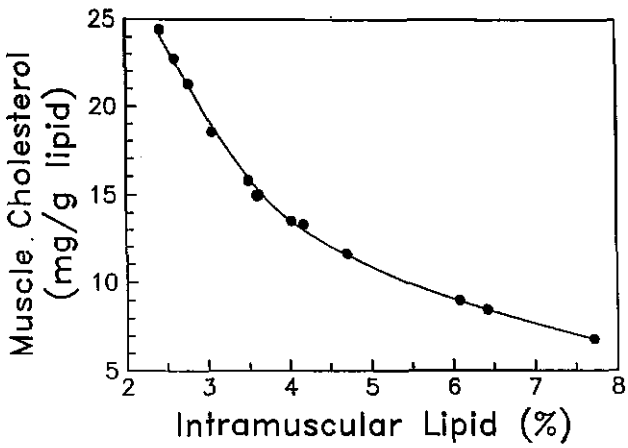

Fig. 1. The relationship between percent muscle lipid and the cholesterol content of the lipid.

since fatty meat is an energy dense food (Thornton and Larsen, 1985) and consumption of excess kilojoules, particularly as ruminant fat which has a low content of polyunsaturated fatty acids, is also linked to increased risk of coronary heart disease.

Rhee *et al.* (1982b) reported that there were no significant differences due to marbling in the cholesterol content of cooked steaks. On a wet weight basis the amount of cholesterol will increase in cooked meat because the weight of a steak is reduced, primarily through removal of water during cooking. The total amount of cholesterol in steak, however, does not increase due to cooking, in fact, it will decrease marginally by the amount lost in the cooking drip.

When cholesterol content was expressed on the basis of mg/g of extracted muscle lipid a curvilinear relationship was present between cholesterol and percent muscle lipid (Fig. 1). When the amount of extractable muscle lipid is low, cholesterol concentration is high, therefore functional membrane lipid contains a higher concentration of cholesterol than does intramuscular adipose tissue lipid. Therefore, since most lipid lost in the cooking drip is adipose tissue lipid, cooking would result in a minimal loss of cholesterol.

Consumers need not be concerned about the presence of marbling in beef steaks since marbling makes only a minimal contribution to the cholesterol content of steak. Functional lipid, associated with muscle cells, is the major source of cholesterol, therefore, cooking will not cause a significant reduction in cholesterol content of meat. Visible fat, however, should be trimmed away from the muscle before cooking to reduce total dietary cholesterol and kilojoules.

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News from the Division

Retirement

B V Chandler

Bruce Chandler joined the Division of Food Preservation and Transport as it then was at Homebush, in 1946, and retired in December 1986 after 40 years of service. He had graduated from Sydney University in 1945 with the degree of BSc (Hons) in Organic Chemistry, and this was the relevant discipline for his first project on the 'isolation and identification of certain products of deterioration occurring in processed citrus juices'.

Orange juice is now so widely consumed in several entirely acceptable forms that it is hard to recall how 'difficult' a product it was once thought to be. The specific problem to which Bruce Chandler was assigned was bitterness in orange juice, known in other countries as affecting navel orange juice but peculiar to Australia as an occasional problem in Valencia orange juice; the bitter principle, limonin, had been known for 100 years but its constitution was then still unknown. Bruce went on to contribute to the chemical elucidation and technological solution of this problem, certainly as much as any other single worker in the world. Working first in the Division, and then on secondment to the Organic Chemistry Department of the University of Sydney under Prof A J Birch, Bruce worked out a chemical structure for limonin which was almost complete; and in fact, its constitution was only finally resolved by the combined efforts of 19 chemists and xray crystallographers in four European and US laboratories. For his work Bruce was awarded a PhD by Sydney University in 1958.

Subsequently Bruce extended his interests in the chemistry of fruit products to embrace anthocyanin pigments and other flavoniods, and he worked in this field at the University of California, Berkeley, and the Low Temperature Research Station, Cambridge.

But the chemistry and technology of citrus products remained Bruce's principal interest. He developed the first quantitative assay of limonin and the first practical procedure for elimination of limonin from citrus juices by adsorption first onto polyamide powder and then, in collaboration with Bob Johnson, on to cellulose acetate beads, themselves a novel adsorbent. Patents were granted in several countries for the bead process and they extended the adsorption studies to the improvement of the quality of grapefruit juice by reducing both acidity and bitterness. With his research team, Bruce studied the complex sequence of enzymic reactions which control bitterness development in citrus juices and obtained evidence for a mechanism for delayed bitterness which differs from that currently accepted. His deep knowledge of citrus chemistry enabled him to develop a series of equations of universal application describing the maturation of citrus crops in terms of chemical parameters.

Bruce also served as CSIRO representative on the Honey Research Committee and compiled a highly regarded CSIRO Technical Bulletin on the chemical composition of Australian honeys.

Within the Division Bruce became successfully Leader of the Food Chemistry Group and then of the group entitled Chemical Bases of Food Acceptance which covered a wide range of investigations from continued citrus studies to the psychophysics of taste and olfaction. In these capacities he earned the respect of his colleagues for his thoughtful and unselfish leadership.

In addition to his scientific activities Bruce contributed greatly to the social life of the Division by organizing a music club and a film society. Bruce is a Fellow of the Australian Institute of Food Science and Technology and was active in committee work for that professional body; in 1977 he was honoured with the AIFST Award of Merit.

Bruce is co-author of the book 'The Chemical Constituents of Citrus Fruits', and author or co-author of more than 50 papers.

It is a melancholy fact of life that the accumulated wisdom of a man such as Bruce Chandler can never, neither by publication or rub-off, be handed on completely to those who follow.

J.F. Kefford

Update on food irradiation

Since publication (*CSIRO Food Research Quarterly*, 1985, **45**, 55-8) of the article 'Status of food irradiation in Australia', the National Health & Medical Research Council (NH&MRC), through its Public Health Committee, has recommended to the Australian States and Territories the adoption of a Model Food Standards Regulation

(MFSR) for the Irradiation of Food. The MFSR is based on the Codex Alimentarius Commission's General Standard of Irradiated Foods and its Recommended Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods. Although the NH&MRC recommendation was made in March 1986, the Australian Minister for Health announced, on 7 August 1986, that the Australian Consumers' Association (ACA), publisher of 'Choice' magazine, is to conduct an independent study into food irradiation.

The Federal Government has contracted with ACA to conduct the inquiry at a cost of $90 000, to 'examine the impact of food irradiation on consumer health and the environment, and the costs to consumers'. The inquiry is expected to take six months.

In addition, the Minister announced, on 23 September 1986, that the All Party House of Representatives Standing Committee on Environment and Conservation would enquire into and report on "the use of ionizing radiation for commercial sterilization, disinfestation, food preservation and other purposes, with particular reference to human health and safety, environmental impacts and the adequacy of assessments of regulatory procedures".

Until the completion of both these enquiries, adoption of the Model Food Standards Regulation will be in abeyance.

Meanwhile, the NH&MRC Working Party on the Food Irradiation Information Program (on which the Division of Food Research is represented) has suspended its activities until the ACA inquiry has been completed.

George Fisher

Food hygiene training package — 'Don't Poison Your Patrons'

The Division has assisted in the production of a high quality food hygiene training package for the food service industry. The package, entitled 'Don't Poison Your Patrons — The Principles of Food Hygiene', introduces people at all levels in food service establishments to the procedures that must be followed to prevent outbreaks of bacterial food poisoning.

The package includes two videotapes, a manual and a handy hints leaflet. The first videotape (19 min) is aimed at managers, supervisors and trainers. It explains the importance of good food hygiene and shows managers and supervisors how to ensure that their staff use acceptable techniques in preparing and storing food. The second videotape (16 min) is aimed at food handlers. It shows food handlers why food hygiene is also their responsibility and demonstrates how to apply the principles of food hygiene in their day-to-day activities. Both videos use a subtle, entertaining approach that avoids stern, disciplinarian methods and negative images.

The manual (55 pages) contains practical information on food hygiene, presented without scientific terminology. After discussing food poisoning and its causes and consequences, the manual describes the principles of food hygiene and how to apply these principles and prevent food poisoning. The manual also contains questions and answers for assessing the effectiveness of training, advice on training staff, and a list of resources, including sources of assistance and further information. The leaflet summarizes the critical points and is designed to be taken home by food handlers.

The structure of the package allows it to be used by people with different types of expertise and varying needs, including: (1) technically qualified people (e.g. health surveyors, food technologists) conducting training, (2) people using the package for self-instruction, (3) managers, supervisors or trainers who need to train others but who do not have formal training in food science. The package is relevant to food service operations of all sizes.

The price of the complete package, containing two videotapes (VHS or Beta), the manual and the leaflet, is $125 plus $5 postage and handling. If required, ¾ inch videotapes are available at extra cost. Additional copies of the individual components of the package are available. Contact Mr Keith Richardson, Industry Liaison Officer at the Food Research Laboratory for order forms or further information.