VEAL PRODUCTION SYSTEMS FOR DAIRY CALVES

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SUMMARY

There is a demand for medium to heavy weight (60-90 kg) pink veal carcasses in Melbourne that is not currently being met. Two experiments are described in which purebred and crossbred Friesian bull calves were fed diets with varying proportions of wholemilk and concentrates and were serially slaughtered from 12 to 22 weeks of age. Carcass quality, rib composition and meat quality were compared statistically at 75 kg carcass weight by regression procedures.

The growth rate of calves fed concentrates only after 8 weeks of age was poor but this may be related to their preweaning management. Calves fed wholemilk and concentrates grew at up to 1.4 kg/day with feed conversion ratios of less than 2 kg dry matter/kg liveweight gain. Crossbred calves did not perform any better than purebreds but they produced carcasses with better conformation, retail yields and higher rib and intramuscular fat contents. Meat colour may become unacceptably dark once carcass weights exceed 60 kg. Too high a level of milk feeding may lead to reduced retail yields and a diet of 10 l/day wholemilk plus concentrates appears about optimum. Further research using milk-free diets is required to produce quality veal using cheaper diets.

INTRODUCTION

Consumers are demanding meat with reduced levels of saturated fats and cholesterol. Because red meat is considered high in these constituents, consumers are now eating less red meat and more white meat such as pork and chicken (McKinna 1984). Veal is low in total lipids and saturated fats (Sinclair 1973) hence is an alternative to white meats. During 1983, a survey was undertaken in Melbourne to gain feedback from 92 wholesale and retail butchers on whether the current level, timing and quality of supplies of veal were satisfactory (Bailey, personal communication). The majority of these butchers were unable to consistently obtain the type of veal they preferred. Medium weight (51-70 kg) veal carcasses were most in demand whereas light (up to 40 kg) carcasses made up the bulk of supply. The quality of veal also varied throughout the year and those heavier (70-90 kg) carcasses that were available were often too dark in colour. Generally there was a glut of smaller calves slaughtered in the spring and an irregular supply of larger calves throughout the year. Retail butchers considered the ideal veal carcass had pale meat colour and good carcass conformation while consumers perceived leaneness of the cuts and the pale meat colour to be the main attributes of veal (Stevens, unpublished data). This historic association between pale meat colour and quality veal is currently being challenged in Europe and North America (Anon. 1986) where traditional systems of rearing veal calves using tethering and low iron milk replacers are gradually being replaced by loose housing and the inclusion of roughage and concentrate in calf diets.

Victoria supplies over 50% of the 1.5 million calves slaughtered annually in Australia. The bulk of these are surplus dairy bull and heifer calves which are milk fed for a short period prior to sale in

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spring. The remainder come from older beef breed calves suckled until 3 to 6 months of age or from a few specialist veal producers. Dairy farmers have the skills and facilities for calf rearing, the colostrum and wholemilk on hand for feeding and the supply of calves. Spring calving is the norm in Victoria as this coincides with peaks in pasture growth, although there are now pressures, particularly in the northern irrigation region, for year-round milk production. Therefore, Victorian dairy farmers have the potential to supply the urban cosmopolitan populations and also export markets with the desired end product. For example, the annual per capita consumption of veal in Australia is only 3 to 4 kg and an increase in consumption of 8.5 kg/head/year could be met by growing out just 15% of the Victoria's week-old calves which are now slaughtered.

Dairy farmers also have the flexibility to vary the proportions of milk and concentrate in veal diets, depending on current wholemilk and veal carcass prices. Wholemilk or milk replacer is the most costly part of growing veal, and, in the UK, it can constitute up to 60% of the total production costs (Paxman 1981). Such an expense may be justified in Europe with their high meat prices but, in Australia, cheaper dietary constituents are necessary. Canadian production sytems for milk-fed or grain-fed veal have been developed (Winter and Lachance 1983) and could be adapted to local conditions. The rearing of vealers (cattle of 6 to 12 months old producing carcasses of 90 to 180 kg) on beef dams at pasture is an established beef system in southern Australia, producing over 20% of the total cattle for slaughter (A.M.R.C. 1976). Therefore, as supplies of pale "bobby" veal and darker meat from suckled vealers are already available, systems of veal production should be directed towards veal from 60 to 90 kg carcasses with meat colour intermediate to bobby veal or vealer.

A project was initiated in Victoria in 1985 to develop systems for producing veal carcasses which meet the requirements of the retail trade and consumers. This paper presents data on growth, feed efficiency and carcass quality of calves grown at Kyabram. Calves were slaughtered at one and nine weeks of age (20-40 kg carcass weight or CWT) and then serially from 12 to 22 weeks of age to follow carcass tissue changes between 40 and 100 kg CWT.

MATERIALS. AND METHODS

In Trial A, purebred Friesian bulls were group reared on wholemilk until 8 weeks of age after which they were group fed (11 animals/group) on one of three diets.

1. Diet M, wholemilk fed ad lib twice daily from a trough.
2. Diet M+C, 11 l/hd/day wholemilk plus ad lib concentrate (wheat : oats : cottonseed meal 47 : 47 : 6).
3. Diet C, ad lib concentrate (wheat : oats : cottonseed meal 37 : 37 : 26) plus chopped hay at 14% total feed intake from 16 to 22 weeks of age.

Long hay was fed to Groups M+C and C between 8 and 16 weeks of age. Animals were slaughtered at one (6 calves), nine (5 calves), 16(5 calves/group) and 22(6 calves/group) weeks of age.

Calves were weighed weekly with growth rates calculated from a regression of liveweight on time. The wholemilk and concentrates were periodically sampled and chemical analysed and concentrate residues were weighed every week. Unfasted slaughter liveweights were obtained 24 h prior to slaughter after which muscle score (points out of 5), leg length and carcass length were recorded. Leg length was defined as the distance between the hook in the achilles tendon and the anterior edge of the symphasis pubis while carcass length was the distance to the cervico-thoracic joint between the 7th and 8th vertebrae. The carcasses were weighed after overnight chilling (2-5°C) and kidney fat was removed and weighed. One side was jointed into hindquarter (hind leg to 13th rib), ribset (5th to 13th rib) and forequarter (fore leg to 5th rib) and these were weighed then separated into retail meat and-bone. Meat colour was recorded subjectively on the M longissimus dorsi (LD) at the 13th rib (with units 1 to 15 with increasing darkness) and the ultimate pH and meat colour were recorded objectively on the M semitendinosus. Meat colour was measured using a Reflectance Chromameter with units for L (lightness), a (red/green) and b (blue/yellow) (MacDougall et al. 1973). The area of LD muscle was later recorded using a planimeter and the 9-10-11 rib joint (Hankins and Howe 1946) was physically dissected into subcutaneous fat (subfat), intermuscular fat (interfat), muscle and bone. These dissected tissues were then ground, mixed and chemically analysed for water, lipid and ash with protein being calculated as the remaining tissue. Intramuscular fat was determined on the LD as was Warner-Bratzler peak shear force. Finally, part of the LD was cooked and tested by a laboratory sensory panel for assessment of tenderness, juiciness and general acceptability.

In Trial B, bull calves were group reared on wholemilk until 7 weeks of age during which time they were given access to concentrate pellets. They were then allocated into four groups of 12 calves and group fed at one of the following levels of wholemilk (offered twice daily in troughs) plus ad lib concentrate pellets

1. Diet 5F, 5 l/hd/day wholemilk, Friesian
2. Diet 10F, 10 l/hd/day wholemilk, Friesian
3. Diet 15F, 15 l/hd/day wholemilk, Friesian
4. Diet 15X, 15 l/hd/day wholemilk, crossbred Hereford x Friesian

The concentrate pellets were made up of barley: full fat soybean meal (85:15) plus a vitamin/mineral premix. Four calves per group were slaughtered at 12, 16 and 20 weeks of age. Liveweight, feed intake, carcass quality and carcass composition measurements were taken as in Trial A except for Warner-Bratzler shear force and taste panel testing.

Trial A was conducted between August and January while Trial B ran from April to August. Each group was loose housed on rice hulls in covered galvanised steel yards and had access to water. Calves in Trial A also had access to dirt yards. Because one animal per trial died during rearing, calves were vaccinated for Clostridia and drenched for gastro-intestinal parasites. During Trial B, the cool damp conditions led to several instances of Pastuerella pneumonia which were duly treated.

Data on liveweights and growth rates were analysed by one way analyses of variance within each trial. Carcass quality and composition data were subjected to regression analyses using all values from within each diet and adjusting the means to 75 kg CWT along a common slope within each trial. Within-diet linear regression coefficients were tested prior to these adjustments and if they were significantly different from one another, adjusted means were not statistically compared. In all tables statistical significance within each trial has been shown by different letters following a value (a, b, c for Trial A and x, y, z for Trial B).

RESULTS

The wholemilk fed to calves in both trials had milk fat contents varying from 4.0 to 4.5%, milk protein contents of 2.8 to 3.4% and total solid contents of 12.7 to 13.3%. Crude protein contents of concentrates fed in Diet M+C, C and to all groups in Trial B were 15.4, 21.0 and 12.6% respectively while corresponding neutral detergent fibre contents were 25.3, 17.5 and 19.7 %. Iron content of the concentrate fed in Trial B was 484 ppm.

Intakes and Growth

Trial A. During the rearing period, the calves grew at 1.1 kg/day weighing 93 kg by 8 weeks of age. Performance data are presented in Table 1. Up to 16 weeks of age, growth rates on Diet C were only 42% those on Diet M, this being partly the result of the rapidity (ie. 2 weeks) with which diets were changed from all milk to all concentrate/hay. They also seemed to prefer the long hay to the concentrate mix on offer, so between 16 and 22 weeks the hay was chopped and mixed with the concentrate. The calves trough fed Diet M drank over 17 l/day, growing at 1.3 kg/day. Another group of similar aged calves were fed naturally acidified wholemilk _ad lib_ via rubber teats from a 200 1 plastic barrel. This is a popular method of rearing heifer replacements on dairy farms but it only led to these veal calves growing at 0.8 kg/day. There were numerous management problems associated with this form of milk feeding (eg. curdled milk which could not be easily drunk, chewed teats, dominant calves restricting access of other calves) and estimated intakes of wholemilk intake for these calves were only 10 to 12 l/day.

TABLE 1. Performance of calves during Trial A

	Age (Wks)	Diet M	M+C	C
Liveweight	16	167.5[c]	152.5[b]	123.1[a]
(kg)	22	218.0[b]	218.5[b]	175.4[a]
Milk intake	8-16	17.4	11.4	-
(l/day)	16-22	19.5	10.0	-
Concentrate intake	8-16	-	0.57	0.99
(kg DM/day)	16-22	-	2.49	3.38
Total DM intake	8-16	2.23	2.38	1.58
(kg/day)	16-22	2.47	3.76	3.95
Growth rate	8-16	1.33[c]	1.05[b]	0.56[a]
(kg/day)	16-22	1.41[a]	1.47[a]	1.43[a]
Feed conversion ratio	8-16	1.68	2.27	2.82
(DMI/growth rate)	16-22	1.75	2.56	2.76

All three groups grew at over 1.4 kg/day between 16 and 22 weeks of age. It is likely that calves fed Diet C showed evidence of compensatory gain during this period. Growth rates of 1.5 kg/day appear the maximum to be expected when fully feeding Friesian bull calves on wholemilk or milk replacer (Paxman 1981). The good overall performance of calves fed Diet M+C prompted the feeding of different combinations of wholemilk and concentrate in the second trial.

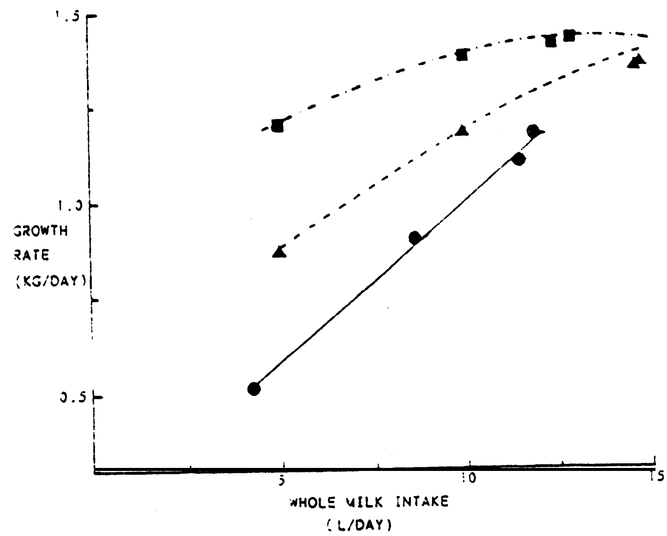
Trial B. To reduce the length of adaptation time after they were placed in their dietary treatments, calves were fed less milk than in Trial A and offered concentrate during the rearing period. Consequently, they grew at 0.8 kg/day weighing 71 kg by 7 weeks of age. Performance data are presented in Table 2. Calves offered 15 l/day milk rarely drank this amount and to maintain the 5 : 10 : 15 ratio of milk consumed, Groups 5F and 10F were offered less milk up to 12 weeks of age. Intakes of wholemilk and concentrate and liveweignts of the Friesian and Hereford x Friesian calves in Groups 15F and 15X did not differ significantly at anytime during the trial. Their growth rates and feed conversion ratios were similar to those on Diet M in Trial A despite their drinking 4-7 l/day less wholemilk. Concentrate intakes increased as less milk was offered but up to 16 weeks of age, this was not sufficient to maintain overall dry matter (DM) intakes which in Group 5F were only 70% of those in the Group 15F. After 16 weeks, the beneficial effects of milk became less apparent as appetite for milk declined (in Groups 15F and 15X) and total DM intakes and growth rates did not differ greatly between groups. However, by 20 weeks of age, the liveweight difference between Groups 5F and 10F (29 kg) was nearly double that between Groups 10F and 15F groups (15 kg).

TABLE 2. Performance of calves during Trial B

	Age (wks)	Diet 5F	10F	15F	15X
Liveweight (kg)	12	89.5^x	102.1^{xy}	108.1^y	112.0^y
	16	117.1^x	140.5^y	151.9^y	158.3^y
	20	147.2^x	176.0^{xy}	191.5^y	202.1^y
Milk intake (l/day)	7-12	4.3	8.6	11.5	11.9
	12-16	5.0	9.9	14.6	14.7
	16-20	5.0	10.0	12.4	12.9
Concentrate intake (kg DM/day)	7-12	0.58	0.30	0.15	0.08
	12-16	1.03	0.72	0.45	0.39
	16-20	1.75	1.32	0.98	0.73
Total DM intake (kg/day)	7-12	1.13	1.41	1.63	1.62
	12-16	1.67	2.00	2.33	2.29
	16-20	2.41	2.55	2.63	2.45
Growth rate (kg/day)	7-12	0.52^x	0.91^y	1.11^y	1.18^y
	12-16	0.87^x	1.18^y	1.36^y	1.36^y
	16-20	1.20^x	1.38^x	1.41^x	1.42^x
Feed conversion ratio (DMI/growth rate)	7-12	2.05	1.55	1.47	1.45
	12-16	1.92	1.69	1.71	1.68
	16-20	2.01	1.85	1.87	1.72
Blood haemoglobin level (g/100ml)	14	13.0^x	12.6^x	13.0^x	13.0^x

Regression equations relating growth rate to wholemilk intake over the various age ranges are presented in Fig. 1. Between 7 and 12 weeks of age, there was a linear relationship with growth rates increasing by 0.08 kg/day for every extra litre of wholemilk consumed. However, at older ages, the responses were smaller and quadratic regressions provided the better fit.

The low iron diets traditionally fed to veal calves are designed to reduce muscle myoglobin levels and hence meat colour. Wholemilk is low in iron and if animals are not given access to other forms of iron (eg. concentrates, galvanized steel pipes and iron sheeting), blood haemoglobin levels can fall below the critical level of 7 g/100 ml (Bremner et al 1976). Blood samples were taken at 14 weeks of age at which time individual blood haemoglobin levels varied from 10.8 to 15.3 g/100 ml and there was no dietary effect (see Table 2).



Plotted equations

7-12 weeks $Y = 0.16 + 0.08 X$ (RSD = 0.024)
12-16 weeks $Y = 0.42 + 0.10 X - 0.0023 X^2$ (RSD = 0.003)
16-20 weeks $Y = 0.88 + 0.08 X - 0.0029 X^2$ (RSD = 0.005)

Fig. 1. Growth rates of calves in Trial B between 7 - 12 (●—●), 12-16 (▲---▲) and 16-20 (■-·-■) weeks of age as influenced by milk intake.

Carcass quality and composition

Data on Tables 3, 4 and 5 are from 7 and 63 day old calves and from all calves in Trials A and B adjusted by linear regression to 75 kg CWT. In Trial A, 75 kg carcasses were attained by 137 days of age in Group C, this being significantly older than the 115 days in Group M+C and 108 days in Group M. In Trial B, animals in Group 5F produced 75 kg carcasses by 122 days of age, this being significantly older than the 111 days in Group 10F, 109 days in Group 15F and 108 days in Group 15X.

The animals on Diet C had the lowest dressing percentage of all groups, even lower than those from 7 or 63 day old calves (Table 3). Furthermore, at 75 kg CWT, they also had less kidney fat, smaller ribsets, lower muscle scores and longer carcass lengths than those arising from Diets M and M+C. The only significant difference between Diets M and M+C was the lower dressing percentage on Diet M+C. In Trial B, the crossbreds produced carcasses with the highest muscle scores and retail yields and the lowest carcass and leg lengths. The only significant difference between Friesian groups in the second trial was the shorter carcass length arising from Diet 15F. Treatment differences in distribution of carcass joints and LD area were generally non-significant in both trials. Yields of retail meat improved from 57% at 21kg to 60% at 41 kg to 68-70% at 75 kg CWT.

Animals fed Diet C were depositing intermuscular fat and lipid at a slower rate and muscle tissue and water at a faster rate than those fed Diets M and M+C (Table 4). Dietary effects were non-significant for rib subcutaneous fat, protein or ash in Trial A, but Diet C led to more rib bone than Diet M and hence a poorer (though non-significant) muscle to bone ratio. The only significant compositional differences in Trial B were more subcutaneous fat and lipid and less water in the ribs of the crossbreds while within the Friesians, those fed 15 l/day had more rib subcutaneous

TABLE 3. Carcass quality at 7 and 63 days of age and at 75 kg carcass weight in Trials A and B

	7d	63 d	Trial A M	Trial A M+C	Trial A C	Trial B 5F	Trial B 10F	Trial B 15F	Trial B 15X
Carcass weight (kg)	20.9	41.1							
Dressing %	48.6	54.4	53.4[c]	51.1[b]	45.7[a]	53.2[x]	54.2[x]	54.6[x]	54.6[x]
Muscle score	0.7	1.7	1.9[b]	1.9[b]	0.8[a]	1.9[x]	1.9[x]	2.0[x]	2.2[y]
Carcass length (mm)	947	1168	1400[a]	1406[a]	1449[b]	1373[x]	1381[x]	1344[y]	1308[z]
Leg length (mm)	361	448	532	527	507	524[x]	530[x]	530[x]	504[y]
Kidney fat (kg)		0.5	1.6[b]	1.5[b]	0.7[a]	1.6[x]	1.6[x]	1.8[x]	1.6[x]
Hindquarters (kg)	9.6	19.6	35.6	36.0	35.1	33.9	34.1	34.0	33.6
Forequarters (kg)	7.6	13.0	25.8[a]	25.4[a]	25.8[a]	25.6[x]	24.9[x]	25.0[x]	24.7[x]
Ribset (kg)	2.6	8.0	14.1[b]	13.8[b]	13.0[a]	12.8	12.9	12.4	13.3
Retail yield (kg)	12.0	24.8	52.8[a]	52.8[a]	51.4[a]	50.1[x]	50.8[x]	50.7[x]	51.8[y]
LD area (cm^2)	14.6	22.2	41.8[a]	40.3[a]	45.4[a]	37.6[x]	39.5[x]	39.0[x]	36.6[x]

Between-diet linear regression coefficients differed ($P<0.05$) with leg length (Trial A), hindquarters (Trials A and B) and ribsets (Trial B).

TABLE 4. Composition of the 9-10-11 rib joint at 7 and 63 days of age and at 75 kg carcass weight in Trials A and B

	7d	63 d	Trial A M	Trial A M+C	Trial A C	Trial B 5F	Trial B 10F	Trial B 15F	Trial B 15X
Physical composition (%)									
Subfat	0.3	0.2	1.8[a]	1.5[a]	0.5[a]	1.6[x]	1.2[x]	3.2[y]	3.8[y]
Interfat	0.3	1.5	4.1	1.2	1.1	4.1[x]	5.6[x]	5.0[x]	6.0[x]
Muscle	67.4	71.8	73.4	75.0	74.5	72.1[x]	70.7[x]	69.7[x]	68.9[x]
Bone	32.0	26.5	19.8[a]	21.0[ab]	22.1[b]	20.7[x]	20.7[x]	20.7[x]	19.5[x]
Muscle : bone	2.11	2.71	3.71[a]	3.57[a]	3.37[a]	3.48[x]	3.42[x]	3.37[x]	3.53[x]
Chemical composition (%)									
Water	71.7	68.3	61.0	64.4	72.7	62.2[y]	61.9[y]	61.0[y]	58.3[x]
Lipid	3.2	5.8	12.5	9.6	4.4	13.6[x]	12.8[x]	14.5[x]	17.8[y]
Protein	11.1	13.3	14.5[a]	12.8[a]	13.5[a]	13.5[x]	14.2[x]	13.1[x]	13.5[x]
Ash	14.0	12.6	10.3[a]	12.1[a]	11.2[a]	10.6[x]	11.2[x]	11.3[x]	10.3[x]

Between-diet linear regression coefficients differed ($P<0.05$) in Trial A with interfat, muscle, water and fat.

TABLE 5. Meat quality at 7 and 63 days of age and at 75 kg carcass weight in Trials A and B

	7d	63 d	Trial A M	Trial A M+C	Trial A C	Trial B 5F	Trial B 10F	Trial B 15F	Trial B 15X
Intramuscular fat (%)	0.51	0.23	0.42[b]	0.22[ab]	0.12[a]	0.43[x]	0.38[x]	0.59[x]	1.12[y]
Meat colour									
L.D. Score			3.5[b]	3.7[b]	2.6[a]	4.1[x]	3.2[x]	3.6[x]	3.2[x]
L Value	50.7	42.9	38.9[a]	38.2[a]	38.9[a]	38.5[x]	38.5[x]	39.8[x]	39.9[x]
a value	9.2	9.5	12.1[a]	12.0[a]	11.4[a]	11.2[x]	11.2[x]	11.5[x]	10.7[x]
b value	6.0	4.7	5.6[a]	5.3[a]	5.1[a]	4.7[x]	4.7[x]	5.6[x]	5.1[x]
Warner-Bratzler shear force (kg)	2.9	2.3	2.8[a]	2.7[a]	3.2[a]	-	-	-	-
Taste panel									
Tenderness	3.8	3.4	2.4[a]	3.0[a]	3.1[a]	-	-	-	-
Juiciness	2.2	2.6	3.0[a]	3.0[a]	3.1[a]	-	-	-	-
Accepatbility	2.6	2.2	2.3[a]	2.5[a]	2.6[a]	-	-	-	-

Taste panel units: Tenderness 1 to 7 with decreasing tenderness
Juiciness 1 to 5 with decreasing juiciness
Acceptability 1 to 5 with decreasing acceptability.

fat than those fed 5 or PO l/day. Week-old calves had a very low rib muscle to bone ratio (2.1) and this improved with age to 2.7 at 9 weeks and 3.4 - 3.7 by the time carcasses weighed 75 kg, through both increases in muscle tissue and decreases in bone. Rib fat also increased with age but the influence of diet was marked, even by 16 weeks, such that in 75 kg carcasses, this varied from 1.6 to 9.8% fatty tissue. On a chemical basis, age effects on rib protein or ash were less marked whereas rib lipid increased from 3.2% at one week of age up to 4.4 - 17.8% at 75 kg CWT.

In Trial A many of the carcasses had very high ultimate muscle pH. A pH of above 5.7 often produces "dark cutting" carcasses in which meat is darker, of variable tenderness, reduced keeping quality and less flavour. This led to the rejection of these data from analyses in Table 5 (except for intramuscular fat in which all data were used), thus reducing numbers to 7, 6 and 9 for Diets M, M+C and C respectively. Carcasses with a high ultimate meat pH were not a problem in Trial B. Dietary effects on meat quality were small. Intramuscular fat content was significantly higher on Diet M than Diet C while crossbreds had higher levels than Friesians in Trial B. There were no significant differences in meat colour L, a or b values in either trial while in Trial A, Diet C led to a higher subjective meat colour score than Diets M and M+C, L value was lower in the older animals. There was little difference in taste panel results although tenderness tended to be poorer in the older animals.

DISCUSSION

To achieve growth rates of at least 1 kg/day in veal calves (ie. 75 kg CWT by 16 weeks of age) and to produce carcasses with high dressing percentages, good conformation and an acceptable level of fatness, these studies indicate that wholemilk should be fed after 8 weeks of age. The interpretations from Trial A are limited in that, to randomly select animals for the three diets, concentrate could not be offered during the rearing phase. Therefore there was no chance to gradually introduce concentrates to those calves on Diet C. The fact that growth rates later in the trial were 1.4 kg/day in these animals suggests that further trials should be conducted on milk-free diets but with a different preweaning management. Winter and Lachance (1983) reported growth rates of over 1 kg/day in Holstein bull calves fed a diet of 75% maize, 25% protein-mineral-vitamin supplement with access to grass hay up to 10% of the concentrate intake. By 16 weeks of age, their animals weighed 141 kg compared to 155 kg for other calves fed entirely on milk replacer. Feed requirements to reach these weights were 20 kg milk replacer plus 250 kg concentrate mix for the grain-fed veal and 181 kg milk replacer for the milk fed veal. In Trial B, calves on Diet 10F produced a 75 kg carcass at 138 kg liveweight by 111 days of age requiring 945 1 of milk and 32 kg of concentrates. At current Victoria prices of $1.20/kg for milk replacer, 16¢/litre for wholemilk and 25¢/kg for concentrates, the total feed costs for these three systems would be $86 (grain-fed), $217 (milk-fed) and $159 (10F). Clearly further work on minimising milk requirements hence feed costs for medium to heavy weight pink veal production systems is important.

The importance of pale meat colour as a determinant of perceived meat quality means that iron levels should be considered in any diet. For example, MacDougall _et al_ (1973) reported L values of veal to decrease from 46 to 38 as dietary iron in milk replacer diets increased from 10 to 100 ppm. Winter and Lachance (1983) concluded that meat colouration did not change in grain-fed veal on diets containing 80 to 200 mg iron; they also stated that this meat was slightly darker than veal from milk-fed calves. Assuming wholemilk had an iron content of 10 ppm, estimated dietary iron levels between 8 and 16 weeks of age in Trial B were 277 (5F), 146 (10F), 77 (15F) and 62(15X) ppm. Diets 10F, 15F and 15X should have been sufficiently low in iron to ensure meat colour remained acceptable. However, meat colour in milk-fed calves in Trial A was not much lighter than those in Trial B, despite the fact that their diet had only 10 ppm iron, although they did have access to dirt yards. The Canadian government legislates on colour criteria for veal grading through using L values on brisket meat (Canada 1985). They have four grades with L values of 50 or more (grade 1), 40 to 49 (grade 2), 30 to 39 (grade 3) and 0 to 29 (grade 4) On this basis, most of the veal produced in our trials was grade 3, wfth grade 2 veal generally being produced by animals slaughtered at 12 weeks of age or less. Using average L values plus regression coefficients of L value on CWT (-0.059 in Trial A and -0.058 units/kg CWT in Trial B), it appears that grade 2 carcasses would be obtained on these production systems at 50 to 60 kg CWT. The L values for meat from 8 to 12 month old bulls and steers in England averages 33 (MacDougall et al. 1973) while Victorian feedlot beef carcasses have meat with L values ranging from 34 to 38 with an occasional sample having a value as high as 40.

The crossbred did not grow any better or efficiently than the purebred Friesians, but they produced carcasses with better conformation, higher retail yields, and higher levels of carcass fatness. These findings agree with those of Jordan et al. (1969) who compared Holsteins and Shorthorn x Holsteins at 58 kg CWT. The greater carcass 'fatness carried through to intramuscular fat to the extent that it was nearly twice the level of that in Friesians fed the same diet. However, this level of intramuscualr or marbling fat (1.1%) is still considerably less than that of the leanest joint of Australian beef surveyed by Sinclair et al. (1984) (viz 2.4% in shin beef). Carcass conformation is important with veal carcasses but to achieve this through growing out crossbred as against purebred dairy calves would lead to $10 to $15 more in the purchase price of the calf.

There were dramatic effects of diet on both growth rates and carcass composition in these trials. The poorer growing calves in Trial A had the lowest rib and intramuscular fat and the highest rib bone. In Trial B, total rib fat increased and rib muscle contents decreased with increasing milk intake. Improved growth rates through higher milk intakes led to increasing carcass lipids and decreasing carcass protein in Friesian calves (Morgan 1969) while Bray et al. (1959) reported higher growth rates, dressing percentages, carcass grades and marbling fat in calves fed milk as against milk plus concentrate. Morgan (1969) noted decreases in yield of edible meat with increasing carcass fatness; the same trend was also apparent in the Friesians in Trial B. Therefore, in veal calves, there may be an optimum level of feeding to obtain good growth rates yet keep carcass fat development to such a rate so as to maximise retail yield of lean meat. The data from Trial B on age at 75 kg CWT, feed conversion ratio and carcass composition indicate that there is little point in feeding more than 10 l/day of wholemilk to Friesian calves with concentrate on offer.

There was little effect of diet on meat quality; this was also reported by Hanning et al. (1957) who assessed veal from the animals used by Bray et al. (1959). Ten of the 32 carcasses from Trial A were rejected because of "dark cutting" carcasses and this indicates preslaughter stress problems. As the method used to consign the calves to the abattoir involved minimum preslaughter stress, it would seem that veal calves are particularly susceptible to "dark cutting." To overcome this problem in Trial B, animals were held for 24 h (without food and water) on-farm following the final weighing, taken to the abattoir (a distance of 2 km) and slaughtered within one hour of arrival.

The future for veal production from dairy calves in Victoria will clearly depend on the price per kg carcass returned to the producer. Bobby calves, the major source of veal at present, can be criticised for poor muscle to bone ratios, low retail yields and small carcass joints. McKinna (1984) considers veal as an "up and coming meat which is particularly popular with young working mothers from upper and upper/middle socio-economic groups and with European ethnic households." Veal can be promoted as an everyday meat, especially amongst the health conscious sectors of the community. The animal welfare lobby needs to be educated that this sort of veal does not come from calves constrained in dark sheds and fed a restricted diet (McKinna 1984). Even with white veal production, there is no advantage in using artifically controlled environments with calves tied up on slatted floors since calves will grow equally fast when loose housed on straw (Quillet 1982). Veal calves should however not be given access to pasture as this darkens the meat at an earlier age (Morris, unpublished data). Furthermore for the first month of life, individual pens would allow for quicker diagnosis and treatment of sick animals and also reduce the incidence of pizzle sucking in later weeks.

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REFERENCES

ANON., (1986). Vet Record July 12 p. 27.

A.M.R.C. (1976). Australian Meat Research Committee Review. No. 31. p. 1., October 1976.

BRAY, R.W., RUPNOW, E.H., HANNING, F.M., ALLEN, N.N. and NLEDERMEIER, R.P. (1959). J. Anim. Sci. 18 : 732.

BREMNER, I., BROCKWAY, J.M., DONNELLY, H.T. and WEBSTER, A.J.F. (1976). Vet Record, Sept. 11 p. 203.

CANADA. (1985). Canada Gazette Part II. 118 (13) : 2696.

HANKINS, O.G. and HOWE, P.E. (1946). U.S. Dept. Agric. Tech. Paper No. 926.

HANNING, F.M, BRAY, R.W., ALLEN, N.N. and NIEDERMEIER, R.P. (1957). Food Tech (USA) 11 : 611.

JORDAN, W.A., LISTER, E.E., CARMAN, G.M., MILES, V. and LOGAN, V.S. (1969). Can. J. Anim. Sci. 49 : 343.

MACDOUGALL, D.B., BREMNER, I. and DALGARNO, A.C. (1973). J. Sci. Fd. Agric., 24 : 1255.

MCKINNA, D. (1984). Consumer Attitudes, Opinions, Perceptions and Useage of Red Meats. Study for Cattle Council of Aust.

MORGAN, J.H.L. (1969). N.Z.J. Agric. Res. 12 : 75.

PAXMAN, P. (1981). In "Alternatives to Intensive Husbandry Systems" p. 95. (Univ. Fed. Anim. Welf : Hertfordshire).

QUILLET, J.P. (1981). In "Welfare and Husbandry of Calves". p. 185. editor J.P. Signoret (Martinus Nijhoff : La Hague).

SINCLAIR, A.J. (1973). N.Z. Agric. Sci. 7 : 198.

SINCLAIR, A.J., LAKAT, L. and DIMITRIADIS, E. (1985). Proc. Nut.Soc. Aust. 10 : 184.

WINTER, K.A. and LACHANCE, B. (1983). Agric. Canada Publ. 1432E.