PRODUCTION OF FLAVOUR-MODIFIED SHEEP MEATS

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INTRODUCTION

Traditionally Australian sheep meats are produced from pasture, with little if any supplementary feeding except in situations such as droughts, where grains may be fed to supplement depleted pastures. The strong "grassy" flavour that pastures tend to impart to the meat are quite acceptable to Australians, however consumers in overseas countries such as Japan, whose consumption of sheep meat is very low, or the U.S.A where the lot-feeding of grain diets to sheep is normal, find this "grassy" flavour or odour unacceptable. Consequently the export of Australian lamb to these two countries is low. In 1986 out of a total lamb production of 316,000 tonnes, only 8,081 and 4,504 tonnes were exported to Japan and the U.S.A respectively (A.M.L.C. 1986). Clearly there is tremendous potential to increase exports of lamb to these markets, if a product of suitable specifications can be economically produced.

It is the aim of this paper to discuss various factors that affect sheep meat flavour during production and present a method of manipulating the flavour of grass fed lambs by dietary means.

FLAVOUR OF SHEEP MEAT

In common with many other natural products, the flavour and odour of sheep meats is complex, comprising numerous volatile components. For instance Caporaso et al. (1977), have identified 51 components in the neutral lipid fraction from ovine adipose tissue and have suggested 14 of these are important contributors to flavour quality. The situation becomes even more complex following cooking where the formation of further compounds can occur. Flament et al. (1976) have identified seven alkylpyrazines that were formed by the thermolysis of the water soluble precursors of flavour in raw meat. It is considered that these alkylpyrazines may be positive contributers to the roasted lamb flavour, as they are generally associated with the pleasant odour of roasted foods (Buttery et al. 1977).

Alkylpyridines have also been isolated from roasted lamb. These compounds are formed presumably from the reaction of aldehydes with ammonia or other amino compounds. Buttery et al. (1977) has suggested that their less-pleasant odour is the reason for the rejection of lamb by some consumers. Similarly the role of branched chain and unsaturated fatty acids of eight to ten carbon atoms are thought also to contribute to the undesirable flavour of cooked mutton (Wong et al. 1975). It has been suggested that these isomeric fatty acids are produced as a result of propionate metabolism from lambs fed diets rich in barley or other cereals (Duncan et al. 1974).

DIET AND FLAVOUR

There is little doubt that diet has a major influence on the flavour of sheep meat. As indicated above, grains such as barley influence the metabolism in the rumen and result in the production of fatty acids that

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produce undesirable odours and flavours in lamb meat (Wong et al. 1975. It is generally accepted that sheep which have been hand-fed cereals and grain have a blander flavour in their cooked meat. It is meat produced from pasture that evokes the greatest response, especially from people who do not usually consume sheep meats (McDonald and Scott 1977). The aroma and flavour of lamb grazed on lucerne (Medicago sativa) has been described by Park et al. (1972a) as being "sharp" and "sickly" compared to that raised on phalaris (Phalaris tuberosa) pasture. Similarly meat produced from lamb grazing winter forage crops such as rape (Brassica napus) have been described as having a "nauseating" aroma and flavour, or vetch (Vicia dasycarpa L. cv. Lana) an intense "meaty" flavour, or oats (Avena sativa cv. Acacia) a "pungent" odour and flavour (Park et al. 1972c). Tropical legumes are not without problems either. Mea-m lambs grazed on glycine (Glycine wightii) have been described as having a characteristic and objectionable odour compared to animals grazed on legumes or native grass pastures (Park et al. 1972b). Identification of the flavour and odour components in these comparisons have not been made, although Park et al. (1972) has described the oat-fed sheep odour as "mercaptan-like". All these odour and flavour findings are based on Australian taste panel comparisons, presumably composed of people who are used to or at least familiar with Australian grass-fed lamb. If meat from these trials had been evaluated by Japanese taste panels the results may have been even more pronounced.

There is little doubt that pasture contributes greatly to the flavour and odour of cooked lamb, however when sheep are taken from pasture and hand-fed diets based on cereals the flavour of the cooked meat becomes more bland (McDonald and Scott 1977).

POLYUNSATURATION AND FLAVOUR

Scott et al.' (1970) demonstrated that the level of linoleic acid (18:2) could be raised to over 20% of the total fatty acids in ruminant milk fat. This was achieved by feeding specific quantities of dietary oils high in 18:2, that were protected from the usual ruminal hydrogenation by micro-encapsulation in formaldehyde treated casein. These supplements produced a similar effect in ruminant adipose tissue (Cook et al. 1970). In a review dealing with polyunsaturated ruminant products, McDonald and Scott (1977) discussed the production of sheep containing elevated levels of 18:2 in their adipose tissue and the properties of the meat. Briefly sheep meat containing 20% 18:2 in the adipose tissue was quite different from pasture fed lamb, having "sweet" and "oily" characteristics attributed to γ-dodec-6-enolactone and deca-2,4-dienal respectively. The meat was often reported to exhibit the flavour of chicken or pork due to the elevated level of the decadienal that improved the flavour to some consumers, especially those who preferred the flavour of non ruminant meats (Park et al. 1975). The presence of the lactone produced less desirable effects in the meat. The "sweet" flavour and odour when present was considered most undesirable. It is considered that this lactone is the major contributor to an objectionable flavour in ruminant products produced with an elevated 18:2 content (Park et al. 1975; Park et al. 1978; McDonald and Scott 1977).

Park et al. (1976) fed two kinds of protected lipid supplements made from sunflower seed and' safflower oil to lambs. They found that both supplements decreased the conventional cooked lamb odour and flavour and increased the "oily" odour attributed to the increased presence of the decadienal. Only the sunflower seed supplement imparted a characteristic "sweet" odour and flavour said to be due to the presence of increased quantities of the unsaturated lactone. This work suggested that it might be possible to manipulate sheep meat flavours by subtle changes to the nature of the lipid, although they fed supplements based on whole sunflower seed and extracted safflower oil. There may be precursors in the non-oil portion of the seed that contribute to the unsaturated lactone formation in cooked meat. However, evidence from trials with dairy cows suggests that the precursors of this unsaturated lactone are in the oil portion of the seed (Urbach and Stark 1978).

FLAVOUR-MODIFIED SHEEP MEAT

Practical considerations

If acceptable flavour modifications are to be made to sheep meat by increasing the level of 18:2 in adipose tissue, it is clear that the "sweet" odour and flavour due to the increased proportion of the unsaturated lactone must be avoided. This need not be a problem in flavour-modified sheep meat production. It has been found that the decadienal responsible for the desirable "oily" flavour and odour increases rapidly on feeding protected lipids, whereas the unsaturated lactone increased more slowly, in proportion to the 18:2 content in the adipose tissue (Park et al. 1975). We have found that if the 18:2 content is kept below 10%, the odour due to γ-dodec-6-enlactone in cooked lamb meat cannot be detected. This is consistent with the data of Park et al. (1978) who attempted to modify the flavour of mutton by feeding protected sunflower seed supplement.

Lipid source and flavour

The influence of the nature of the lipid on meat flavour has been investigated in lambs. Lambs of 30 kg live weight were fed protected lipid supplements for four weeks at a rate of 250 g/d/sheep. The basal ration (1 kg/d/sheep) consisted of maize, sunflower meal (38% CP) and cotton hull (5:3:2). Supplements were prepared from sunflower kernel, cotton oil, peanut kernel and rendered beef tallow as lipid sources and sunflower meal and casein as protein sources by procedures outlined by Ashes et al. (1979). All supplements were produced to contain 30% lipid on a dry matter basis (D.M.B.). The lambs (six/group) were taken from pasture and fed the supplements for four weeks, slaughtered and the cooked meat assessed by an A.M.L.C. (Australian Meat and Livestock Corporation) taste panel for flavour. The panel was not trained in flavour comparisons but asked to give an impression of the meat flavour compared to control meat produced from the basal ration alone. The results are shown in Table 1.

TABLE 1 The effect of lipid source on lamb flavour

Lipid	18:2 in adipose tissue (%)	Flavour description
Sunflower	12.0	Pork-like
Peanut	7.0	Slightly nutty, lamb
Cotton	9.7	Bland, lamb
Beef	4.0	Strongly lamb

Meat from this trial was also evaluated under supervision of the A.M.L.C. by representatives of eight Japanese meat importing companies who were asked to indicate their lamb flavour preference during and after cooking using traditional Japanese and conventional roasting technques. They reported (unpublished results) that when compared to the control meat the usual "grassy" cooking odour of Australian lamb was eliminated. There was a flavour preference for lamb fed supplements produced from cotton or peanut lipids, where the flavour of the lamb was still present, but without the stronger "grassy" flavours found with pasture fed animals.

This trial indicated that it was possible to vary the flavour of lamb meat to meet certain market requirements. While flavour components were not measured it is probable that the deca-2,4-dienal levels of the meat from sheep fed polyunsaturated lipid increased, masking or counteracting the strong pasture flavours and cooking odours (Park et al. 1975). However there also must have been a flavour contribution from each of the lipid sources transferred to the meat to further change the flavour, as the 18:2 contents of the meats were not greatly different, except for the lamb fed beef tallow supplements, the lipid of which contained only low levels of 18:2. In all meat there was no obvious presence of the unsaturated lactone.

Production of flavour-modified lamb

From a consumer view-point, taste and marketing trials conducted in Japan (A.C. Rich, personal communication) indicated that lamb containing six percent 18:2 in their adipose tissue and produced from protected cotton kernel supplement has a bland flavour with little offensive cooking odour. . An empty body weight of 18-22 kg is required with a fat score of two to three. This corresponds to a final live weight of 35-38 kg. Little information is available on preferred genotype or age, however a larger framed wether lamb of 10 months is preferred. In practice lambs from crossbred Border Leicester x Merino ewes to Dorset rams are acceptable if not ideal. In the future the sheep industry must look into suitable breeds that provide the carcass size and degree of fatness required if Australia is to compete in the export of prime lamb to newer world markets.

TABLE 2 Diet composition for flavour-modified lambs

Component	g/d
Protected cotton seed	250
Cotton hulls	300
Maize	300
Lupin	200
Wheat	150
Lime	15
Sodium chloride	15
Bentonite	20

The 18:2 content in adipose tissue can be achieved by feeding sheep from pasture of initial live weight 28-30 kg, a protected cotton seed supplement at a rate of 250 g/d/sheep for 21 d in a feedlot. In addition to the supplement a concentrate ration is fed at the rate of 1 kg/d/sheep. A typical diet is shown in table 2 where growth rates of approximately 300 g/d with feed conversion ratios of 4:1 can be obtained from sheep under normal conditions found in the feedlot.

The physical form of the diet will be important if the production Of flavour modified lambs is to become economically viable. Protected lipid supplements are only moderately palatable and selection from the diet should be minimised. Pelleting these materials in the past was not successful (McDonald and Scott 1977). Protected lipid supplements are susceptible to damage at elevated temperatures and pressures, as the encapsulated lipid microdroplets can be squeezed out of the protein matrix. This results in reduced lipid protection in the rumen and consequently lower 18:2 in the adipose tissue. However recent trials have been more successful, where whole diets have been pelleted through thinner dies designed to minimise the heat and pressure generated during pelleting. Two groups of five animals were fed the same diet as shown in table 2 as a loose mix or ground and pelleted for 21 d. The mean percent 18:2 of the adipose tissue for the two groups was 5.34 ± 2.96 and 4.49 ± 0.76 respectively. The range of values of the group fed the loose mix went from 2.19 to 9.31 percent, while the number for the group fed the pellets was much less ranging from 3.64 to 5.50 percent. This trial indicated that while pelleting reduced the mean 18:2 content of the adipose tissue by a non significant amount ($P = 0.57$), it has reduced the variation by preventing component selection from the loose mix diet. This reduction is important for quality control, as the range of animals produced with either high 18:2 contents, potentially containing the undesirable "sweet" lactone flavour, or with insufficient 18:2 to increase the decadienal level to mask the cooking odour (Park et al. 1975), will be reduced.

Quality control during production of flavour modified lambs is a problem as the 18:2 content of adipose tissue is critical. The lamb is produced for the quality section of the export market, consequently there can be little carcass variation permitted. It is possible that weight gain in the feedlot may be used as a guide to 18:2 content in adipose tissue as time constraints in exporting chilled meat virtually eliminate the use of gas chromatography on large numbers of samples. The relationship between liveweight gain and 18:2 content for lambs fed a diet similar to that given in table 2 for 21 d is represented by the equation:

$$\%18{:}2 = 0.326\ (20.094)\ \text{liveweight gain} + 4.602\ (\pm 0.655)$$

This relationship was linear ($r = 0.373$, $P < 0.05$) and was obtained from data from 80 lambs consuming a loose mixed diet. Weight gain may be even a more useful indicator of 18:2 content of adipose tissue for animals consuming pelleted rations where individual variations will be further reduced.

CONCLUSIONS

Diet plays a very important role in sheep meat production. There are many pasture flavours that are transferred to the meat and many substances that are produced during the digestive processes or are contained in the diet that can react during cooking to produce undesirable flavours and odours. In general meat from sheep fed concentrate diets is likely to be blander than from pasture fed animals, but there are certain grains and other components that contribute to undesirable flavours in the meat due to specific metabolic effects. The feeding of protected lipid supplements can be used to modify the flavour of meat from sheep raised on pasture by masking the strong grassy flavours and odours. Sufficient supplement must be fed'to lambs to produce six percent 18:2 in the adipose tissue over a two to three week period. By varying the lipid source a range of flavours can be produced to meet consumer requirements. Japanese consumers have a preference for meat with a bland lamb flavour without the usual "grassy" cooking odour found in Australian lamb raised on pasture. Lamb with these characteristics can be produced from supplements manufactured from cotton seed lipids fed in conjunction with a high concentrate low roughage diet in a feedlot.

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REFERENCES

A.M.L.C. (1986). "Ann. Rep. Aust. Meat Livestock Corp" 1985-86, pp. 54-5.

ASHES, J.R., GULATI, S.K., COOK, L.J., SCOTT, J.W., and DONNELLY, J.B. (1979). J. Am. Oil Chem. Soc. 56: 522.

BUTTERY, R.G., LING, L.C., TERANISHI, R., and MON, T.R. (1977)e J. Agric. Food Chem. 25: 1227.

CAPORASO, F., SINK, J.D., DIMICK, P.S., MUSINAN,C.J.,and SANDERSON, A. (1977)e J. Agric. Food Chem. 25: 1230.

COOK, L.J., SCOTT, T.W., FERGUSON, K.A., and McDONALD, I.W. (1970)e Nature 228: 178.

DUNCAN, M.R.H., LOUGH, A.K., and GARTON, G.A.(1974). Lipids 9: 669.

FLAMENT, I., KOHLER, M., and ASCHIERO, R. (1976)e Helv. Chim. Acta 59: 2308.

McDONALD, I.W., and SCOTT, T.W (1977). Wld Rev. Nutr. Diet. 26: 144.

PARK, R.J., CORBETT, J.L., and FURNIVAL, E.P. (1972a). J. Agric. Sci., Camb. 79: 47.

PARK, R.J., and MINSON, D.J. (1972b). J. Agric. Sci., Camb. 79: 473.

PARK, R.J., SPURWAY, R.A., and WHEELER, J.L. (1972c). J. Agric. Sci., Camb. 78: 53.

PARK, R.J., FORD, A.L., and RATCLIFF, D. (1975). J. Food Sci. 40: 1217.

PARK, R.J., FORD, A.L., and RATCLIFF, De (1976). J. Food Sci. 41: 633.

PARK, R.J., FORD, A.L., and RATCLIFFE, D. (1978). J. Food Sci. 43: 874.

SCOTT, T.W. t COOK, L.J. t FERGUSON, K.A., McDONALD, I.W., BUCHANAN, R.A., and LOFTUS HILLS, G. (1970). Aust. J. Sci. 32: 291.

WONG, E., NIXON, L.N., and JOHNSON, C.B. (1975). J. Agric. Food Chem. 23: 495 .

URBACH, G. 8 and STARK, W. (1978). J. Dairy Res. 45: 223.