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Beef Quality Assessed at European Research Centres

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SUMMARY

Loin steaks and cubes of M. semimembranosus *from eight (12 month old) Galloway steers and eight (16–18 month old) Charolais cross steers raised in England and from which the meat was conditioned for 2 or 10 days, were assessed in research centres in Belgium, Denmark, England, France, the Federal Republic of Germany, Ireland, Italy and the Netherlands. Laboratory panels assessed meat by grilling the steaks and cooking the cubes in casseroles according to local custom using scales developed locally and by scales used frequently at other research centres.*

The meat was mostly of good quality but with sufficient variation to obtain meaningful comparisons. Tenderness and juiciness were assessed most, and flavour least, consistently. Over the 32 meats, acceptability of steaks and casseroles was in general compounded from tenderness, juiciness and flavour. However, when the meat was tough, it dominated the overall judgement; but when tender, flavour played an important rôle. Irish and English panels tended to weight more on flavour and Italian panels on tenderness and juiciness. Juiciness and tenderness were well correlated among all panels except in Italy and Germany. With flavour, however, Belgian, Irish, German and Dutch panels ranked the meats similarly and formed a group distinct from the others which did not. The panels showed a similar grouping for judgements of acceptability.

French and Belgian panels judged the steaks from the older Charolais cross steers to have more flavour and be more juicy than average and tended to prefer them. Casseroles from younger steers were invariably preferred although the French and Belgian panels judged aged meat from older animals equally acceptable. These regional biases were thought to be derived mainly from differences in cooking, but variations in experience and perception of assessors also contributed.

INTRODUCTION

If research in beef production programmes is to remain relevant to changing consumer demands it is essential that it is carried through to studies of the desirability of meat as a food. This implies not only measurement of product quality but also consumer preference. Whilst it is clear that preferences vary between individuals, differences have also been recognised between races and even among people of the same race separated geographically. Preferences for foods can be influenced by the physical, social and technological factors (Jerome, 1977) and by the desirability of 'primary tastes'. For example, Nigerians and Koreans, but not Americans, preferred sweetened tomato juice (Druz & Baldwin, 1982). Such preferences can be readily studied in manufactured foods produced to precise specifications, but are difficult to characterise in carcass meats. In beef, the use of different production systems (Cunningham, 1977), butchery (Brown & Fisher, 1982) and cooking methods (Jeremiah, 1982) in different countries implies that those factors may also influence preference and acceptability of carcass meats.

In a previous attempt to study the effect of production factors and acceptance (Dransfield *et al.*, 1982), the quality of steaks from beef produced in eight regions of Europe was assessed at centres in Belgium, France, Germany, Ireland and the United Kingdom. Acceptability of those commercial meats varied widely due mainly to differences in post-slaughter handling which produced a wide range of texture. Flavour and juiciness of the steaks varied little. Tenderness was highly correlated among the centres and use of a common scale established that scores were directly comparable despite a variety of cooking procedures, with end point temperatures ranging from 50° to 75°C. Texture so dominated acceptability that it was considered inappropriate to study any detailed relationships of components of acceptability or the influence of production on other attributes. An attempt was made to study these relationships in this second trial in which texture was controlled (by using meat which was slaughtered and chilled under controlled conditions) and in which flavour and juiciness were deliberately varied by including two cooking methods.

EXPERIMENTAL

Meat

Eight Galloway steers (12 months old) from one farm and eight Charolais cross steers (18 months old) from another were laired with food and water *ad libitum* for 48 or 72 h. Animals were slaughtered in an abattoir approved for intracommunity trade and the carcasses were held at ambient temperature for 4 to 6 h, then placed in a chill-room operating between 7° and 10°C. After 24 h, when the deep leg temperatures ranged from 14° to 22°C, the carcasses were transferred to a 1°C chill-room.

At approximately 36 h the carcasses were cut into boneless primal joints. Sirloins (9th rib to last lumbar vertebra) and topside joints from both sides of four Charolais cross and four Galloway carcasses were vacuum packed and stored at 1 °C for a further 2 days and the sides of the other four Charolais cross and four Galloway carcasses for 10 days. After storage each sirloin was cut into 21 steaks approximately 2·5 cm thick. Adjacent pairs of steaks from eight locations along the *M. longissimus dorsi* (LD) were allotted to each centre. The same location from the opposite side of the carcass was used as a replicate and those paired samples were tested at two (replicate) sessions. The same procedure was followed for all carcasses except that a different location from each carcass was assigned to a centre; therefore, each centre tested each location once. The *M. semimembranosus* (Sm), was dissected from the topside joint and was cut into approximately 2 cm cubes. The cubes from left and right muscles from the same carcass were tested in two (replicate) sessions. Cubes from each muscle were allocated at random to centres.

Steaks and cubes were then vacuum-packed, frozen and stored at −25 °C. After storage for 1 month (except samples for the centre in Italy, which were stored for 2 months) the samples were transferred to boxes insulated with 5 cm thick polystyrene. On the day of transport 9·5 kg of 'dry-ice' was placed in the insulated boxes for flights to Ireland, Belgium and The Netherlands and approximately 18 kg for flights to Germany, Italy, Denmark and France. All samples were kept frozen during transit and transfers to testing centres were completed within 36 h.

Organoleptic assessments

Sensory evaluation panels were used at: Slagteriernes Forskningsinstitut (SF), Denmark; the Meat Research Institute (MRI), Great Britain; The Agricultural Institute (AFT), Ireland; the Station de Recherches sur la Viande (INRA), France; Bundesanstalt fur Fleischforschung (BF), Federal Republic of Germany; University of Ghent (UG), Faculty of Agricultural Science, Laboratory of Organic Chemistry, Belgium; Istituto di Produzione Animale (IPA), Universita Napoli, Italy, and Centraal Instituut voor Voedingsonderzoek (CIV), TNO, The Netherlands.

Each testing centre used its standard methodology for eating quality evaluation. Steaks were grilled and Sm cubes cooked in casseroles (Sm is rarely cooked domestically in casseroles but it was convenient to do so here because it is a large uniform muscle and cooking in casseroles is common in all the countries studied). The sensory scales used were those developed independently at each centre and an additional flavour intensity scale common to all centres was also used. All steaks and cubes were assessed hot. Four LD samples (conditioned and unconditioned from Charolais and Galloway steers) were tested at each of eight sessions and the testing repeated with replicate samples from the other side of the carcass. Casseroles were tested similarly.

The SF, Roskilde, panel was composed of ten housewives from a nearby town who were experienced in taste panel work and whose ages ranged from 33 to 65 years. Steaks were thawed at 20 °C for 1–2 h and then trimmed to 2·5 cm thickness. Steaks were heated without additional fat on a griddle at 170 °C, turned every 3 min and cooked for 12 min—a method designed to produce fried steaks with pink centres. The Sm cubes were prepared as a goulash. The cubes were browned for 5 min in 20 g margarine; 300 ml of water were added and the mixture was allowed to simmer for 55 min.

The MRI, Langford, panel of twelve people experienced in panel procedures was drawn from the institute staff. Steaks were thawed overnight, then trimmed to 2·5 cm thickness. Approximately 15 min before panelling, a large commercial electric grill was switched on at its highest setting. A Chromel–Alumel wire thermocouple was inserted into the centre of each steak, using a hollow needle. Each steak was cooked for about 5 min on each side until the internal temperature reached 75 °C. Cubes were weighed and cooked in casseroles in equal weight of 0·9 % saline. The casseroles were then covered and placed in pre-heated ovens set at 170 °C for 1·75 h.

The AFT, Dublin, panel was comprised of ten assessors selected from the institute staff. Steaks were thawed and then grilled on a catering grill set at 'high', for 7 min each side, producing a medium to well-done steak with a centre temperature of about 70 °C. The Sm cubes were browned under a grill, without added fat in aluminium foil dishes; 100 ml of water were added and the dishes were covered and put in an oven set at 150 °C for 1·5 h.

At CIV, Zeist, steaks were heated for 4 min in a contact grill (Kuechenmeister) to an internal temperature of 50° to 55 °C. Cubes of Sm were heated for 50 min in water at 75 °C.

At UG, Ghent, the steaks were thawed overnight (20 h at 2° to 3 °C) then cooked for 2 min in a contact grill set at 'high', producing a rare steak with a centre temperature of 50 °C. Cubes of Sm were cooked in water for 50 min at 75 °C.

At INRA, Theix, steaks were thawed and grilled to a centre temperature of 50 °C. They were judged by twelve assessors selected from the institute staff. The Sm cubes were cooked in water for 2 h.

At BF, Kulmbach, steaks were thawed overnight and grilled for 6 min in a contact grill (Turmix, Switzerland). The Sm cubes were placed in 130 ml of boiling water and boiled for 6 min.

At IPA, Portici, steaks were grilled under a commercial electric grill set at 130 °C and switched on 15 min before cooking commenced. Steaks were turned every minute and cooked to an internal temperature of 75 °C. The Sm cubes were placed in an open pressure cooker with three cloves of garlic and a little olive oil and margarine. They were browned (10 min), the garlic was removed and a bouillon cube plus a little water added. The pressure cooker was closed and the cubes cooked for 30 min. Eating quality was assessed by eight members of staff.

Scales

All panels used category scales; those at BF, SF, INRA, MRI and AFT were referred to in detail in a previous comparison (Dransfield *et al.*, 1982) and therefore only the outlines are given here.

Tenderness

All panels except BF and SF used an eight-point scale (four categories of toughness and four of tenderness) and scored −7 to 7 in two-unit increments. BF used a 6-point scale (three categories of toughness and three of tenderness) scored 1 to 6. SF used an 11-point scale (five categories of tenderness, a centre category, 'neither good nor bad', and five of toughness) scored −5 through 0 to 5.

Flavour

A common flavour scale: extremely weak, very weak, moderately weak, slightly weak, slightly strong, moderately strong, very strong and extremely strong (scored −7 to 7 in two-unit increments) was used by all centres except AFT. Local scales of flavour intensity were used at MRI, AFT and IPA (four categories scored 0 to 3). Hedonic scales were used at AFT (six categories scored −5 to 5), BF (six categories scored 1 to 6) and at SF (eleven categories scored −5 through 0 to 5).

Juiciness

Several different scales were used: MRI, AFT and IPA used a 5-point scale, one category 'dry' and the other four 'juicy' and scored 0 to 4; most other scales were balanced: BF used three categories of dryness and three of juiciness (scored 1 to 6), INRA used four (scored −7 to 7) and SF five of each and a central category (scored −5 through 0 to 5). CIV used a bipolar unbalanced scale of three categories of dryness and five of juiciness (scored −7 to 7).

Acceptability

Eight category scales (poor/unacceptable to good/acceptable, scored −7 to 7) were used at MRI, CIV, UG, AFT, INRA and IPA. BF used six categories (scored 1 to 6) and SF eleven categories (scored −5 through 0 to 5).

Analyses

Discrimination of each attribute of each panel was measured by the *F* ratio calculated from analysis of variance. The variance due to animal was calculated relative to the residual, excluding the variance due to tasters and session.

The relationships among attributes within a panel were estimated by correlation and by estimating the relative positions of the attributes in multidimensional space. The multidimensional spaces of the attributes for each assessor were centralised, expanded or contracted to equal volumes and then rotated to minimise the distances between attributes (Gower, 1971). The resulting distances were displayed in multidimensional space using principal co-ordinate analysis (Gower, 1966; Harries & MacFie, 1976). Relationships between panels were estimated by correlation.

RESULTS

Beef quality

Quality assessments are summarised in Tables 1 and 2 as means of the four treatment groups—meat from young animals, conditioned 2 days

TABLE 1

Eating Quality of LD Steaks

For eight research centres, using the scoring system indicated, the overall means for eight animals in each of four treatment groups (YG2 and YG10, young Galloway beef conditioned 2 and 10 days, respectively and OC2 and OC10, older Charolais beef conditioned similarly) are given together with their least significant difference (LSD, 5 %) between groups and the F ratio between animals (+, $p < 0{\cdot}05$; others, non-significant)

Centre	*Scale*	*YG2*	*YG10*	*OC2*	*OC10*	*LSD*	F *ratio*
Tenderness							
MRI	−7 to 7	2·6	2·1	−0·1	0·9	0·5	9+
INRA	−7 to 7	2·1	2·0	−0·6	2·0	0·7	13+
SF	−5 to 5	2·7	2·6	1·6	2·7	0·4	5+
BF	1 to 6	5·0	4·5	4·2	4·4	0·3	6+
AFT	−7 to 7	1·8	2·7	1·3	2·7	0·8	5+
CIV	−7 to 7	1·2	1·7	0·4	1·6	0·6	3+
IPA	−7 to 7	2·1	2·2	0·6	2·0	0·7	4+
UG	−7 to 7	3·6	4·2	3·4	3·5	0·6	3+
Flavour							
MRI	−7 to 7	1·9	1·8	2·1	2·0	0·5	1
INRA	−7 to 7	−1·0	−0·5	1·0	0·3	0·7	4+
SF	−7 to 7	2·0	2·6	2·9	3·0	0·7	2+
BF	−7 to 7	3·2	3·1	3·0	3·2	0·4	1
AFT	0 to 3	1·7	1·8	1·7	1·9	0·2	1
CIV	−7 to 7	2·2	2·3	2·3	2·1	0·5	1
IPA	−7 to 7	1·4	1·6	1·4	1·6	0·5	1
UG	−7 to 7	3·3	3·5	4·1	4·1	0·4	1
Juiciness							
MRI	0 to 4	1·4	1·2	1·7	1·5	0·2	3+
INRA	−7 to 7	0·7	0·5	2·3	1·4	0·6	4+
SF	−5 to 5	2·4	2·1	3·0	2·3	0·4	6+
BF	1 to 6	4·3	3·8	3·8	3·6	0·3	3+
AFT	0 to 4	1·4	1·4	1·5	1·9	0·3	1
CIV	−7 to 7	0·6	0·5	1·7	0·8	0·5	4+
IPA	0 to 4	1·8	1·8	1·7	1·9	0·2	2+
UG	−7 to 7	1·8	2·3	3·5	3·2	0·7	4+
Acceptability							
MRI	−7 to 7	1·7	1·6	1·7	1·9	0·5	1
INRA	−7 to 7	0·5	0·6	1·0	1·2	0·7	1
SF	−5 to 5	2·0	2·0	2·2	2·2	0·4	2+
BF	1 to 6	4·5	4·3	3·9	4·1	0·3	2+
AFT	−7 to 7	2·5	2·7	2·1	2·6	0·7	2
CIV	−7 to 7	1·6	2·0	1·8	2·0	0·6	2
IPA	−7 to 7	2·3	2·2	1·5	2·2	0·5	3+
UG	−7 to 7	3·2	3·8	4·0	3·6	0·5	2

TABLE 2

Eating Quality of Sm Casseroles

For eight research centres using the scoring systems indicated, the overall means for eight animals in each of four treatment groups (YG2 and YG10, young Galloway beef conditioned 2 and 10 days, respectively and OC2 and OC10, older Charollais beef conditioned similarly) are given together with their least significant difference (LSD, 5%) between groups and the F ratio between animals (+, $p < 0.05$; others, non-significant)

Centre	*Scale*	*YG2*	*YG10*	*OC2*	*OC10*	*LSD*	F *ratio*
Tenderness							
MRI	−7 to 7	1·8	2·9	−0·6	1·2	0·7	7+
INRA	−7 to 7	2·0	2·0	−1·6	1·0	0·8	10+
SF	−5 to 5	2·8	3·0	2·3	2·4	0·5	2
BF	1 to 6	3·3	3·2	2·5	2·4	0·4	2+
AFT	−7 to 7	2·9	3·1	−0·3	1·5	1·1	6+
CIV	−7 to 7	−0·0	−0·4	−2·4	−2·5	0·8	5+
IPA	−7 to 7	3·3	3·8	1·7	2·8	0·5	5+
UG	−7 to 7	1·6	1·2	0·5	1·3	0·9	5+
Flavour							
MRI	−7 to 7	1·6	1·4	1·4	1·1	0·5	1
INRA	−7 to 7	0·1	0·0	0·8	−0·1	0·6	2
SF	−7 to 7	2·8	2·6	2·4	2·7	0·6	1
BF	−7 to 7	1·9	1·7	1·3	1·2	0·3	2
AFT	0 to 3	1·1	1·1	1·1	1·0	0·2	0
CIV	−7 to 7	2·1	1·6	1·0	0·6	0·5	2+
IPA	−7 to 7	2·6	2·7	1·9	2·2	0·4	1
UG	−7 to 7	2·3	1·8	2·4	1·2	0·8	2+
Juiciness							
MRI	0 to 4	1·1	1·0	1·1	0·7	0·2	3+
INRA	−7 to 7	−1·3	−3·0	2·1	−2·8	0·6	4+
SF	−5 to 5	0·8	0·2	−0·0	−0·4	0·4	3+
BF	1 to 6	4·2	3·8	3·5	3·5	0·3	3+
AFT	0 to 4	0·3	0·2	0·1	0·1	0·2	1
CIV	−7 to 7	−1·3	−1·8	−2·3	−2·6	0·7	7+
IPA	0 to 4	1·8	1·8	1·6	1·6	0·2	2
UG	−7 to 7	0·7	0·2	0·7	0·5	0·8	7+
Acceptability							
MRI	−7 to 7	1·4	1·1	0·4	0·6	0·5	2+
INRA	−7 to 7	1·3	0·4	−0·7	0·4	0·7	3+
SF	−5 to 5	2·2	2·1	1·5	1·5	0·4	3+
BF	1 to 6	3·4	3·2	2·7	2·6	0·3	2+
AFT	−7 to 7	0·8	0·6	−0·4	−0·1	0·6	1
CIV	−7 to 7	0·8	0·2	−1·3	−1·5	0·7	5+
IPA	−7 to 7	3·3	3·4	1·9	2·5	0·5	4+
UG	−7 to 7	2·0	1·4	1·1	1·4	0·9	5+

(YG2); young animals, conditioned 10 days (YG10); older animals, conditioned 2 days (OC2) and older animals, conditioned 10 days (OC10).

Tenderness

Tenderness of the LD steaks (Table 1) was influenced by animal age and by conditioning time. At INRA, SF, CIV and IPA the older unconditioned (OC2) group were judged tougher than the other groups which were similar. At AFT, conditioning time had the greatest influence, tenderness was 1 point higher in meat conditioned 10 days than in meat conditioned 2 days. At MRI, animal age had the major influence, meat from young Galloways was 2 points more tender than that from the older Charolais crosses. Interactions between animal age and conditioning time were particularly noticeable at UG and BF where YG10 was more tender than YG2 but OC10 was no more tender than OC2 and the four groups were all very tender. Between centres, UG was unusual in classifying the meat moderately tender overall (3·7), whilst AFT and IPA scored about 2 and MRI, INRA and CIV about 1·3, i.e. panels differed by up to one category (2 points). On a pro rata basis, the overall mean of 4·5 on a scale of 1 to 6 at BF is equivalent to 2·8 on a scale of -7 to 7 and, similarly, the 2·4 obtained at SF is equivalent to 3·4.

In casseroles, Sm meat from younger Galloway steers was generally more tender than that from older Charolais animals (Table 2). This was most evident at CIV, BF and SF. At INRA, AFT and IPA, OC10 was more tender than OC2 but it was still not as tender as beef from YG steers conditioned for 2 or 10 days, which were similar. At MRI, YG was more tender than OC and conditioning had a large tenderising effect on both YG and OC steers. At UG, the OC2 beef was least tender, the other three groups (YG2, YG10 and OC10) were equally tender. Major differences were found between panels CIV assessed all four groups as tough whilst SF, IPA and UG assessed them all as tender. At BF and CIV both OC groups were tough whilst at INRA, MRI and AFT the OC2 group was tough and the OC10 tender.

Flavour

In LD steaks the four treatment (production) groups had little influence on flavour intensity (Table 1), with exceptions at INRA and UG where older Charolais (OC) beef had slightly more flavour. Although INRA also assessed the YG steaks drier than OC (Table 1), there was no significant correlation ($r = 0{\cdot}3$) between the animal means for juiciness and flavour. UG also found YG steaks drier than OC (Table 1) but their flavour tended to increase ($r = 0{\cdot}6$) with juiciness. Similar trends were found at MRI and at SF where the young unconditioned beef lacked flavour. Major differences were found between panels: INRA found a lack (scored −0·1) of flavour overall and UG a strong flavour (3·8) overall.

Effects in Sm cubes (Table 2) differed from those in steaks; indeed, IPA, CIV and BF found that meat cooked in casseroles from young Galloways had more flavour—the opposite to that in steaks. Most panels (MRI, INRA, BF, CIV, UG) found that conditioned meat had less flavour. Comparing panels, INRA found least flavour (0·2) and SF the most (2·6).

Juiciness

With LD steaks the influence of the four production (treatment) groups was different at the different panels (Table 1). The most consistent trend (at MRI, SF, INRA and CIV) was that OC2 was most juicy although BF judged YG2 and AFT judged OC10 the most juicy, and IPA found no difference between the groups. That trend was compounded by differences due to conditioning. INRA and UG found OC more juicy than YG while at MRI conditioned meat was slightly drier in both OC and YG. Overall, the panels' judgements were similar and judged 'slightly juicy'.

With Sm cubes (Table 2), UG found no differences between the groups whilst AFT, IPA, SF and CIV found OC drier than YG. At SF, CIV and INRA, conditioned meat was drier. At MRI OC10 was the driest and at BF YG2 was the most juicy. INRA, SF, AFT and CIV found the meat dry.

Acceptability

Overall, the steaks were acceptable and there was little difference between the four groups of meat (Table 1). The IPA panel in particular liked least the unconditioned meat from older animals (OC2) and a similar trend occurred at BF and AFT, whilst the opposite was found at UG who tended to prefer the older unconditioned type of meat. Animal groups (OC, YG) generally had little effect except at INRA where older Charolais cross meat was most acceptable whilst at BF younger Galloway beef was preferred. UG liked the steaks the most (scoring 3·7) and INRA the least (0·8).

With casseroles (Table 2) most panels (MRI, SF, BF, AFT, CIV and IPA) found the meat from older Charolais less acceptable than that from young Galloway with little effect of conditioning. Most panels, and most significantly at INRA, found that YG2 was most acceptable and OC2 least acceptable.

Sensory evaluation

Within each panel (which were orthogonal for assessor and samples) the performance of each assessor was tested against that of the other assessors using principal co-ordinate analysis (not presented). There was no evidence of grouping of assessors or of any unique assessors common to both steak and casseroles and no assessors were discarded.

The variance (F) ratio for 'animal' quantifies the ability of a panel to discriminate reliably between samples of meat from the same animal tasted at two sessions. Although the value is arbitrary, since it depends on the samples used, it is useful here for comparing the performance of the different analytical panels who tasted similar samples to a common schedule. Tenderness varied significantly between animals in all panels for steaks (Table 1) and in all panels except SF for casseroles (Table 2). Juiciness varied significantly between animals in all panels except AFT for steaks (Table 1) and in all panels except AFT and IPA for casseroles (Table 2). Flavour intensity varied inconsistently, with only INRA and SF finding consistent variation with steaks (Table 1) and only CIV and UG finding differences in casseroles (Table 2). In overall acceptability SF, BF and IPA found significant variation between steaks (Table 1) and only AFT failed to record significant differences between casseroles (Table 2).

From the matrices of 16 animals × 10 assessors for each panel, principal co-ordinates analyses showed that 81–99% of the difference between attributes in steaks and 74–99% in Sm cubes was accounted for in two dimensions which are shown for steaks in Fig. 1 and for Sm cubes in Fig. 2. With LD steaks the flavour intensity and hedonic flavour assessments were related, appearing close together in the principal co-ordinate plot (Fig. 1) and the dual scales used for flavour intensity were related at MRI and, to a lesser extent, at IPA. Within centres, linear simple correlation coefficients between flavour scales for steaks and Sm

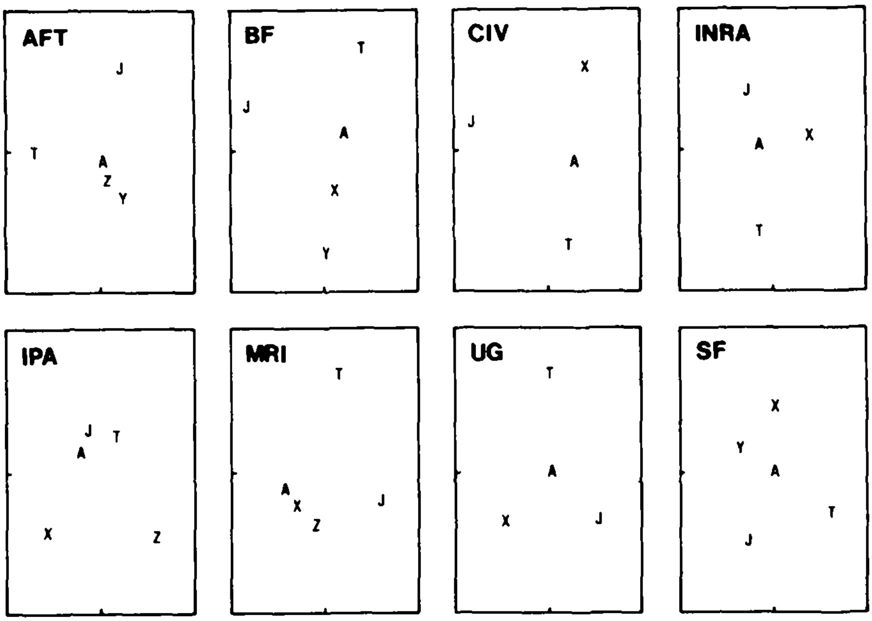

Fig. 1. Interrelationships of attributes of LD steaks. For each panel (AFT, BF, CIV, INRA, IPA, MRI, UG and SF) the co-ordinates of each attribute are plotted relative to the first two principal axes (principal co-ordinates analysis). The attributes are: *T*, tenderness; *J*, juiciness; *X*, common flavour intensity; *Y*, local hedonic flavour; *Z*, local flavour intensity and *A*, acceptability.

cubes, respectively were 0·7 and 0·7 at MRI, 0·7 and 0·6 at IPA; 0·1 and 0·6 at BF and 0·8 and 0·5 at SF (see Figs 1 and 2). Tenderness, juiciness and flavour were well distinguished at all centres. Acceptability was often positioned centrally, showing that the other three attributes contributed equally to it. Exceptions to this were found at AFT and MRI where flavour, and at IPA, where texture (tenderness and juiciness), was more closely associated with acceptability. With casseroles (Fig. 2) the hedonic flavour scale was related to the intensity flavour scale and the dual scales for flavour intensity were related at MRI and, to a lesser extent, at IPA. Tenderness, juiciness and flavour were distinguished at all centres. Unlike that of the steaks, the acceptability of casseroles was often dominated by one or two of the other attributes. At AFT, BF and MRI flavour had the greatest influence; at CIV, IPA and, to a lesser extent, at INRA and UG, tenderness dominated and at SF juiciness was least important.

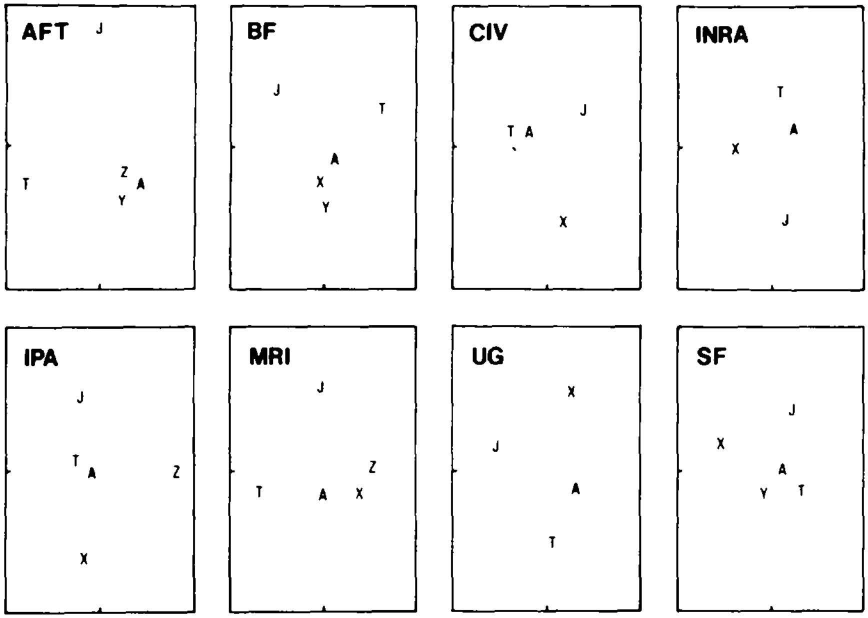

Fig. 2. Interrelationships of attributes of Sm casseroles. For each panel (AFT, BF, CIV, INRA, IPA, MRI, UG and SF) the co-ordinates of each attribute are plotted relative to the first two principal axes (principal co-ordinates analysis). The attributes are: *T*, tenderness; *J*, juiciness; *X*, common flavour intensity; *Y*, local hedonic flavour; *Z*, local flavour intensity and *A*, acceptability.

Relationships between panels

The relationship between panels (summarised in Table 3) was determined by linear correlation using panel mean scores for each sample and for each attribute separately. Coefficients greater than 0·33 are significant ($p < 0{\cdot}05$).

Tenderness

Combining steak and casserole data (Table 3), correlation coefficients between panels varied from −0·2 to 0·8 and there was little evidence of high or low coefficients being associated with any panel or group of panels; most panels had both high and low coefficients. With steaks and casseroles separately (not given) all correlation coefficients were positive and varied from 0·2 to 0·8, again with no evidence of grouping among the panels.

TABLE 3

Relationships Between Eating Quality Assessments of Panels

Values are linear correlation coefficients between panel means for sixteen LD steaks and 16 Sm casseroles pooled. Flavour is the common scale except at AFT where the local intensity scale was used.

	UG	*CIV*	*AFT*	*BF*	*INRA*	*SF*	*MRI*
Tenderness							
IPA	−0·13	0·03	0·47	−0·21	0·56	0·52	0·57
UG	1·00	0·75	0·49	0·78	0·36	0·05	0·22
CIV		1·00	0·56	0·81	0·50	0·28	0·49
AFT			1·00	0·33	0·58	0·40	0·56
BF				1·00	0·39	0·14	0·34
INRA					1·00	0·63	0·72
SF						1·00	0·66
Flavour							
IPA	−0·53	−0·17	−0·64	−0·54	0·09	0·33	−0·18
UG	1·00	0·67	0·71	0·74	0·08	0·21	0·46
CIV		1·00	0·59	0·66	−0·16	0·31	0·41
AFT			1·00	0·82	−0·13	0·04	0·27
BF				1·00	−0·13	0·03	0·34
INRA					1·00	0·27	0·02
SF						1·00	0·44
Juiciness							
IPA	0·19	0·41	0·32	0·19	0·32	0·39	0·09
UG	1·00	0·62	0·77	−0·07	0·79	0·77	0·56
CIV		1·00	0·77	−0·11	0·71	0·87	0·68
AFT			1·00	0·11	0·87	0·85	0·68
BF				1·00	0·10	0·10	0·11
INRA					1·00	0·81	0·70
SF						1·00	0·75
Acceptability							
IPA	−0·28	−0·05	−0·18	−0·12	0·20	0·19	0·04
UG	1·00	0·75	0·76	0·75	0·34	0·42	0·54
CIV		1·00	0·72	0·78	0·47	0·63	0·71
AFT			1·00	0·86	0·49	0·32	0·44
BF				1·00	0·39	0·41	0·59
INRA					1·00	0·43	0·28
SF						1·00	0·68

Flavour

UG, AFT, BF and, to a lesser extent, CIV, formed a group of panels which were highly interrelated. The INRA panel was most individualistic with SF and MRI intermediate. IPA was significantly and negatively correlated with UG, AFT and BF and positively with SF. Similar trends occurred in steaks and casseroles although with lower coefficients except in steaks when IPA was related to SF ($r = 0{\cdot}6$) and with CIV ($r = 0{\cdot}5$) and in casseroles when IPA was related to CIV ($r = 0{\cdot}5$) and to BF ($r = 0{\cdot}7$).

Juiciness

Juiciness assessments were well related ($r = 0{\cdot}6$ to $0{\cdot}9$) among all panels except IPA and BF. Some correlation coefficients with IPA were significant but none was significant with BF. Similar patterns existed in steaks and casseroles; the highest correlation coefficients (up to 0·8) were obtained in casseroles. IPA and BF discriminated the samples as well as the other panels and found as much variation between treatments (Tables 1 and 2).

Acceptability

Four panels (UG, CIV, AFT and BF) formed a group which were well correlated ($r = 0{\cdot}7$ to $0{\cdot}9$). To a lesser extent ($r = 0{\cdot}3$ to $0{\cdot}7$) MRI and SF were associated with this group, INRA was weakly associated ($r = 0{\cdot}3$ to $0{\cdot}5$) and IPA not associated ($r < 0{\cdot}3$). Steaks alone gave a similar pattern although correlation coefficients ($-0{\cdot}3$ to $0{\cdot}6$) were lower than with steaks and casseroles pooled. With casseroles IPA was associated with CIV (0·7), BF (0·7), INRA (0·7), MRI (0·6) and with SF (0·5).

DISCUSSION

The acceptability of steaks and beef cooked in casseroles was determined by contributions from flavour, tenderness and juiciness. The inter-relationship of attributes could be studied more thoroughly in this than in the previous trial (Dransfield *et al.*, 1982) when meat was obtained from commercial abattoirs in member countries and when tenderness dominated acceptability. Within a taste panel the interrelationships of flavour, tenderness and juiciness were often similar in steak and in casseroles, and acceptability was a balance of all three attributes. There was considerable variation between panels. Despite their similar cooking temperatures, acceptability at MRI and AFT was dominated by flavour, while at IPA tenderness was most important. Although we cannot be certain, it is likely that these differences between trained panels would also occur between consumers in those regions, since training enhances acuity but does not alter the relationship of components of a (texture) profile (Cardello *et al.*, 1982).

Panels used scales which varied from five to eleven categories and there was a tendency for shorter scales to be less discriminating. For example, panels at AFT and IPA used the shortest (five category) scales and did not detect significant variation in juiciness between animals in steaks (AFT) or in either cut (IPA). As these two panels used different cooking temperatures and other panels, which used similar cooking temperatures but with longer scales, were able to discriminate between animals, the effect cannot be ascribed to temperature. It does not necessarily follow that other attributes would have been discriminated less well had five category scales been used. Indeed, a 5-point scale was as effective as a 7-point rating scale in assessing the firmness of cheese (Harper, 1972). Tenderness varied more than the other attributes. Comparing the relationships between panels, it was to be expected that correlation coefficients would be lower than in previous trials (Cross *et al.*, 1978; Dransfield *et al.*, 1982) since tenderness was deliberately controlled. There was little evidence that particular panels systematically behaved differently from others, and the occasional minor differences in ranking of the production groups would need to be substantiated before their importance could be assessed.

Juiciness was highly correlated among panels except at IPA and BF. Although we have no adequate explanation for the poor correlation of those two panels, the previous comparisons (Dransfield *et al.*, 1982) showed the BF panel to be unusual in their high discrimination of the importance of juiciness in steaks. The generally high correlations of juiciness confirm that the previously low correlations (Cross *et al.*, 1978; Dransfield *et al.*, 1982) were due to low variation in juiciness rather than to fundamental differences in perception.

Flavour was assessed least consistently between centres. With steaks, the variation between animals was significant only at INRA and SF and not at UG, CIV and BF, where similar low cooking temperatures were used. CIV and UG, which used the mildest form of cooking in casseroles, were the only two panels to find significant differences with casseroles. Flavour differences between centres were therefore due to differences in acuity as well as differences in methodology. Unfortunately, there are no other similar studies of beef flavour for comparison. One clear aim would be to improve our assessment of flavour, perhaps by concentrating on relationships of profiles generated within each centre, particularly in relation to the different cooking temperatures employed (see below). Use of the common scale was, with few exceptions, as good as the local scale and was related to hedonic scales at AFT and, to a lesser extent, at SF. Although correlations were generally low, they were higher between UG, CIV, AFT and BF than in the previous trial.

In the first comparative trial the commercial samples used varied widely in texture and had probably been cold-shortened. Controlling the post-mortem chilling and conditioning in this trial produced fewer tough meats (Dransfield *et al.*, 1982). In the previous, and in this, trial there was little evidence of production factors affecting quality in different ways at different institutes, a possible exception being flavour. At UG and INRA steaks from younger animals were considered drier, to have less flavour and, although more tender, they were less acceptable than meat from older Charolais animals. Whilst INRA and UG appear to be behaving similarly for flavour, which influenced their judgement of acceptability, their judgements of acceptability differed by 1·5 (in eight) categories in steaks which is more than between any other two panels. In general, panels were within one category of each other. Although INRA and UG ranked animal groups similarly, the absolute values differed by nearly one-fifth of the scale. The evidence suggests that this higher acceptability of meat from older Charolais resulted from the low end point cooking temperatures used at those two centres rather than a difference in perception. No difference in flavour between younger Galloway and older Charolais cross beef in casseroles was detected at any centre and, in steaks, the difference observed at INRA and UG (grilling to 50 °C) was not observed in other centres cooking to 55 °C or above. It is also possible that the effect at UG was compounded by variations in juiciness since about 35 % of the variation in flavour could be accounted for by variations in juiciness. At INRA, however, this explanation is unlikely since flavour and juiciness were not significantly related. Although cooking steaks to 50 °C may be the norm in France and Belgium, it appears to be unusual in other countries. In Missouri, USA, 24% of consumers cook meat rare whilst only 10% do so in Arizona (Jeremiah, 1982). These classes of cooking would also include meats cooked as high as 60 °C, probably too high to give rise to the bias observed at UG and INRA. In Alberta, Canada, 10% of the population fried steaks for less than 10 min (Jeremiah, 1982). In the UK and Ireland, fewer consumers are likely to prefer rare steak since only 3% eat rare roasts (MPE, 1981). As far as laboratory methodology is concerned, it is conventional to serve meat cooked at a temperature most frequently used domestically in that region although our results indicate this may not be the most discriminating method. Because laboratory panels are essentially analytical and because the composition (and therefore preferences) of the panel may change, we should consider selection of cooking methods to give the most discriminating assessment rather than selecting those methods preferred by the bulk of the population. This would inevitably lead to the rejection of, and the refusal or unwillingness of, some assessors to take part in panels, but this should be little, or no, more than with conventional methodology.

Quality assessment is an integral part of beef production programmes and relies heavily on sensory testing for measurement and interpretation of consumer reaction and marketing potential. Whilst it is accepted that assessors differ and much work has been done to characterise those differences, very few studies have attempted to relate different panels, which inevitably vary in methodology and assessors. Extremes of methodology were found in those European meat laboratories where meat production and cooking are traditional. Comparisons showed that texture (tenderness and juiciness) was strongly related among countries and variations in production affected texture and acceptability. Flavour was assessed least well and assessments could not be predicted accurately between the laboratories. It is interesting to speculate that it is because texture (tenderness and juiciness) is distinct and more universal than flavour assessment, that texture research has had most impact on fresh meat production.

After considering the literature and the results of the comparisons of sensory testing of beef between centres, the EEC Working Group could find little evidence to recommend standardising to a particular scale length or to a particular cooking method for sensory testing but was able to establish equivalence in tenderness and juiciness assessments, and quantify small, but nevertheless important, regional biases.

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