4 Dimensions of flavour perception between Normal and DFD beef.

M.A. FRANCOMBE AND H.J.H. MACFIE

AFRC Meat Research Institute, Langford, Bristol, U.K.

INTRODUCTION

It is difficult to establish a descriptive vocabulary for the assessment of the range of flavours normally occurring in cooked beef. One alternative is for assessors to score the overall dissimilarity in flavour for every paired combination of treatments. The results can then be analysed by a mathematical procedure called Individual Differences Scaling (INDSCAL) (Carroll and Chang, 1970).

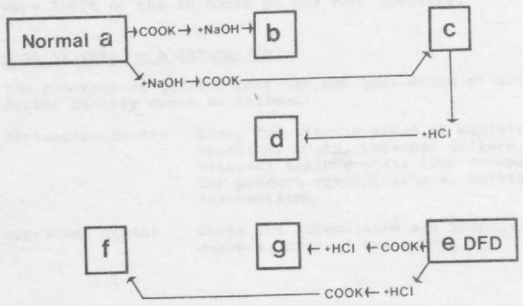
This paper reports the application of dissimilarity scaling of flavour followed by INDSCAL to determine whether difference in pH, independent of other chemical and textural variables, contributes to differences in flavour between 'normal' ultimate pH and high ultimate pH (dark cutting or DFD) beef.

The experimental methods were based on previous studies using dissimilarity scaling and INDSCAL analysis which indicated the advantages of using a balanced factorial design in testing sensory effects of experimental variables (Thomson, 1981; MacFie and Thomson, 1981). Since the application of the method to judgements of flavour, mouthfeel and appearance of cooked beef homogenates had shown appearance and flavour to vary together (Thomson, 1981), we chose to assess flavour in the absence of variation in texture or appearance.

METHODOLOGY

Design

The basic design is summarized in Figure 1. Seven samples a - e were constructed from 'normal' or DFD beef by adjusting the pH before or after cooking.



Preparation of extracts

Six muscles, of ultimate pH 6.2, comprising two M.longissimus dorsi, two M.semitendinosus, one M.semimembranosus and one M.psoas major, were dissected from the carcasses of 2 Friesian bulls aged 12 - 15 months. Six equivalent muscles averaging pHu 5.8 were removed from 2 similar bull carcasses. To prepare homogenates, muscles of similar pHu, aged for 10 days in vacuum-packs in a chiller operating at +1°C, were diced, frozen to -28°C in a blast freezer overnight, then mixed thoroughly before mincing frozen meat twice through a 4mm plate. One kg portions of minced beef of mean pHu 5.8 ('normal') and of mean pHu 6.2 ('high') were separately vacuum-packed and stored for up to 9 weeks at approximately -20°C.

Homogenates were freeze-dried for 6 - 7 days prior to treatment, in 2 kg batches each of 'normal' pHu and DFD beef and then reconstituted into units of 185 g (average wet weight) either with fresh distilled water, 0.032M Analar sodium hydroxide or 0.032M Aristar hydrochloric acid.

Table 1:
Adjustment of pH : pH values and quantities of additives are averages of 8 preparations.

Treatment	Original pH	pH before cooking	pH of extract	Additives before cooking		Additives after cooking	
a	5.8	5.8	5.9	H_2O	138 ml	-	-
b	5.8	5.8	6.2	H_2O	138 ml	0.2M NaOH	3.54 mmol
c	5.8	6.1	6.3	0.032M NaOH	4.43 mmol	-	-
d	5.8	6.1	5.9	0.032M NaOH	4.43 mmol	0.2M HCl	3.42 mmol
e	6.2	6.2	6.3	H_2O	145 ml	-	-
f	6.2	5.8	6.0	0.032M HCl	4.50 mmol	-	-
g	6.2	6.2	6.0	H_2O	145 ml	0.2M HCl	3.42 mmol

After cooking units for 1 hour in a waterbath at 80°C, extracts were prepared by pouring boiling water over homogenates so that the total liquid added after cooking (including pH adjustment) was equivalent to the original moisture content of the meat.

Taste Panel Procedure.

Prior to tasting, extracts were thawed, 7 ml dispensed into individual coded 60 ml amber glass reagent bottles and heated by microwave oven to an average temperature of 53.5 + 3°C. Since a preliminary trial had shown that assessors gave higher flavour difference scores for paired meat samples served at 50°C than 20°C or 35°C, temperature of extracts was maintained at 50°C during tasting sessions.

Eight assessors, 5 males and 3 females aged 24-52, from the staff of the Meat Research Institute, were chosen for their prior experience of meat flavour assessments using the pairwise dissimilarity scoring method.

At each session, assessors scored overall flavour differences for each of 5 pairs of extracts (a standard reference pair plus 4 out of a possible 28 test pairs) by assigning a number for the size of difference using their own scales. No constraints on magnitude or direction were imposed. Assessments were made by tasting extracts through drinking straws to avoid visual clues. Pairs of extracts were presented in random order, each sample differently coded. The experiment was replicated 3 times preserving the serving order but using different codes.

Preliminary Analyses.

Scores for 'same treatment' pairs were used to check individuals performance by comparing with 'between-treatment' scores to give a 'signal:noise' ratio, as defined by Schiffman, Reynolds and Young (1981). The dissimilarity scores were arranged in 24 triangular 7 x 7 matrices, one for each replicate of each assessor, excluding scores for reference and 'same treatment' comparisons. The matrices were then submitted to the INDSCAL programme available in MDS(X) computing package (Coxon et al., 1977).

Individual Differences Scaling Analysis.

The objective of the INDSCAL analysis is to achieve a map of the samples such that the inter-distances of the sample points best represent the consensus of the assessors' inter-sample difference scores. The analysis thus produces coordinates for each sample relative to a number of axes (or dimensions) specified by the experimenter.

The fundamental hypothesis that underlies INDSCAL is that the differences in scoring pattern among the assessors can be accounted for in terms of varying attention (importance or salience) on the dimensions of the sample space. This has been fully discussed elsewhere (Carroll and Chang, 1970). The analysis thus produces a set of weights for each assessor that indicates the relative importance of the dimensions. Weights are also produced for each of the three replicates.

RESULTS.

Dimensionality and Individual Behaviour

The dimensionality of the INDSCAL solution is the minimum number of dimensions that adequately accounts for the scores of each assessor. If an assessor does not perceive a particular dimension, a zero or negative weight will be fitted (Schiffman et al., 1981). The dimensionality for each assessor is reached when there can be no further significant improvement (as judged by the experimenter) in the correlations of the computed scores with his original scores by increasing the number of dimensions in the solution. The dimensionality of the consensus solution must take into account the maximum number of dimensions for all assessors. In this experiment the best solution was 3-dimensional, although only two dimensions are weighted in replicate III, and no assessor weighted all three dimensions.

The average overall correlation of the solution with original data is 0.62 (Table 2), representing 38.4% of the variation in scores. However, correlations for individual assessors range from 0.83 (assessor 3), accounting for 70% of variation in his data, to 0.40 (assessor 2), which may indicate either random scoring or that the individual has responded to dimensions in the stimuli not represented in the consensus solution. When assessor discrimination was checked, all assessors had 'signal:noise' ratios greater than 1.0, and all except assessor 2 had ratios above 1.4. The INDSCAL solution best represents data from assessors 3, 4, 5 and 8 (Table 2), but there is significant correlation with all assessors except those of assessor 2.

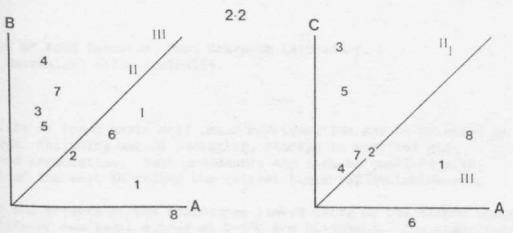
Table 2 Assessor correlations with overall INDSCAL solution: (average of 3 replicates).

	Assessor 1	2	3	4	5	6	7	8
Correlation	0.54	0.40	0.83	0.65	0.64	0.52	0.59	0.78

Overall correlation = 0.62 + 0.15

The relative importance (weighting) of dimensions, averaged over 3 replicate tastings for each assessor, is summarised in Figure 2. Dimension A is weighted by assessors 8, 1 and 6, assessors 4, 7, 3 and 5 find dimension B, and C is used by 3 and 5. No-one strongly weights more than two dimensions and assessors 6 and 8 are not weighted at all on dimensions C and B, respectively. Assessor 2 is poorly weighted on all three dimensions, lying close to the origin in each plot. The overall fluctuation in dimensionality with replicate is also illustrated; A and B are increasingly recognised in replicate I, II and III with a trend towards B, and C is dropped in III, as was indicated previously (Table 3).

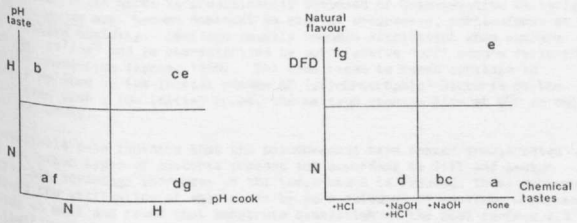
Figure 2.



Interpretation of the Stimulus Space

The experimental treatments (Table 1) might be expected to produce four flavour dimensions, if altering pH at cooking and tasting had independent effects, if other factors besides pH caused flavour difference between 'normal' pHu and DFD beef and if added chemicals affected the taste. These are illustrated in the pairwise plots of Figures 3.1 and 3.2 to aid interpretation of the recovered stimulus space.

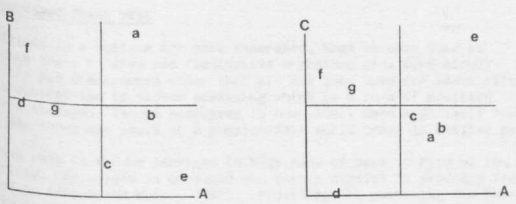
Figure 3



The horizontal axis in Figure 3.2 is a 'chemical taste' dimension producing an arbitrary ordering of the treatments into the following groups of stimuli: 'natural' (a, e), 'added NaOH' (b, c), 'added HCl' (f, g) or 'added NaOH and HCl' (d) that would result if chemical additives caused qualitative flavour differences. It should be noted that it is the grouping rather than the ordering of these samples that is important. Furthermore this dimension, if detected, would not be directly attributable to pH variation.

Comparing the three dimensional stimulus space recovered by INDSCAL displayed in Figure 4 with Figure 3 reveals the following interpretation.

Figure 4



Dimension A is similar to the 'chemical tastes'axis of Fig 3.2 in that treatments a, e, b and c are separate from f, d and g. The expected grouping into four different tastes (Fig 3.2) was not recovered since treatments with HCl added were similar tasting whether NaOH was present or not, and extracts with added NaOH only were closer in taste to those without additives.

Dimension B orders the extracts in the exact inverse of the order obtained by projecting the points in Figure 3.1 on to the line bisecting the 'pH taste' and 'pH cook' axis. This dimension implies that assessors could perceive flavour differences of a similar type whether pH was adjusted before or after cooking. Adjustment of pH before cooking produced a greater flavour difference (e.g. treatment c is further from a than from b) than after cooking, and correspondingly, required a greater amount of acid or alkali to change the pH (see Table 1). The dimension is therefore interpreted as a combined effect of both pH and titratable acidity on flavour.

Dimension C corresponds well with the 'natural' flavour axis in Figure 3.2. Thus 'dark-cutting' (DFD) beef extracts (e, f, g) rank higher than 'normal' samples (a - d). Treatment d is distinct from treatments a - c and evidently the flavour of this extract differed most from the essential flavour of 'dark-cutting' beef.

The dimensions of the space are not independent of each other; dimensions A and B, and B and C are negatively correlated (-0.34 and -0.25, respectively) and A and C are positively correlated (0.30) (Table 3). The intercorrelation of dimensions may be due to the stimuli having factors in common, e.g. treatments b and c are both high pH at tasting made from 'normal' beef adjusted with NaOH, differing only in pH at cooking; likewise, f and g differ only in pH at cooking, but are normal pH at tasting.

CONCLUSIONS.

Three dimensions of flavour variation were recovered from assessors scores of overall dissimilarity among 7 beef extracts using INDSCAL analysis. The consensus solution correlated best with scores from assessors 3, 4, 5 and 8 and were significantly correlated with all except scores given by assessor 2, who was also the least discriminating. Assessors differed in their weighting of dimensions, and no one weighted highly more than two of the three dimensions. Over three repeat tastings, some assessors' weighting of dimensions shifted with replicate, for assessors 3 and 5 to the extent that dimension C, perceived in replicates I and II, was not recovered in III.

From the ordering of treatments along dimensions, A was interpreted as a distinction of flavours due to the chemicals added to adjust pH; B separated treatments on the basis of pH and titratable acidity at tasting, and dimension C distinguished originally 'normal' pHu and DFD beef, but was unrelated to pH. Dimensions B and C both separated 'normal' pHu and DFD beef extracts, suggesting that not only pH and titratable acidity but a second unidentified variable contributed to the flavour differences between them.

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