Development of a model to predict consumer acceptance of cottage pie from sensory quality and salt content

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Within the UK, salt consumption is well above recommended values for sodium intake and poses great risk to health.

The greatest proportion (75 - 80%) can be attributed to processed foods (IFST, 1999).

The COMA Report and the Food Standards Agency have recommended a reduction of 30% in dietary salt intake (DOH, 1991; FSA, 2002).
Reducing salt in processed foods can potentially lead to loss of flavour, texture, product yield and eventual loss of revenue.

The AIM of this preliminary study was to develop a model to predict consumer acceptance from sensory quality and (reduced) salt content.
Methodology

- 8 samples (0.67% - 0%) of processed cottage pie.
- Trained QDA panel (n=10):
  - used to evaluate the effects of a reduction in salt on sensory characteristics;
  - samples evaluated in triplicate using a balanced block design.
- Consumer panel (9-point Hedonic scale) (n=80):
  - used to evaluate the acceptance of samples;
  - samples evaluated once in random order.
A Principal Component Analysis was applied to the 15 sensory attributes extracting 3 PCs that explained 56.5% of the variance in the data.

- PC1 represented a “salt” dimension
- PC2 represented “flavour and quality”
- PC3 represented an “aroma and sauce consistency” dimension

Linear regression was used to predict acceptance, Y, for each consumer in terms of sensory PCs:

\[ Y = b_0 + b_1.PC1 + b_2.PC2 + b_3.PC3 \]
Introducing Added Salt to the Model

- PC1 was strongly associated with added salt (r=0.990) and so a second linear regression was done to relate PC1 to added salt, X
  - \( PC1 = a + b.X \)
- This was substituted into the model for Y
  - \( Y = a' + b1'.X + b2.PC2 + b3.PC3 \)
  - where \( a' = b0+b1.a \) and \( b1' = b1.b \)
- There were wide variations for all 4 regression coefficients
Statistical Analysis

- An exploratory hierarchical cluster analysis produced a dendrogram that was inspected leading to a decision to use 4 clusters.
- Hierarchical cluster analysis applied to the regression coefficients of the extended model. Used to highlight clusters of consumers whose acceptance was related to salt and sensory quality in different ways.
- Series of ANOVAs including cluster as a between subjects effect to reveal significant differences between clusters.
Results

The Consumer Clusters

- Cluster 1 (n=26) characterised by preference for low flavour and aroma
- Cluster 2 (n=14) characterised by preference for high flavour and aroma
- Cluster 3 (n=36) not as sensitive to sensory quality as clusters 1 and 2
- Cluster 4 (n=4) had largest increase in acceptance per unit added salt
- Cluster 1 is the only group for whom product acceptance decreases with added salt
## Results

### Comparing the Clusters

<table>
<thead>
<tr>
<th>Cluster</th>
<th>$a'$</th>
<th>$b_1'$</th>
<th>$b_2$</th>
<th>$b_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n=26)</td>
<td>6.3</td>
<td>-1.9</td>
<td>-5.9</td>
<td>-6.5</td>
</tr>
<tr>
<td>2 (n=14)</td>
<td>2.6</td>
<td>9.0</td>
<td>7.2</td>
<td>4.6</td>
</tr>
<tr>
<td>3 (n=36)</td>
<td>4.1</td>
<td>4.4</td>
<td>0.1</td>
<td>-1.9</td>
</tr>
<tr>
<td>4 (n=4)</td>
<td>1.5</td>
<td>11.6</td>
<td>13.6</td>
<td>12.7</td>
</tr>
<tr>
<td>F(3,76)</td>
<td>22.8$^\wedge$</td>
<td>49.7$^\wedge$</td>
<td>162.3$^*$</td>
<td>115.9$^*$</td>
</tr>
</tbody>
</table>

* $P<0.001$ with Bonferroni post hoc tests revealing differences between each pair of clusters, $^\wedge P< 0.001$ with Bonferroni post hoc tests revealing differences between each pair of clusters except 2 and 4.
Results

The effect of added salt on product acceptance for an average product

PC2 = 0.0, PC3 = 0.0
Alternative Models that could have been used to analyse optimal added salt

- Linear models classify consumers into those for whom acceptance
  - improves with added salt
  - improves with reduced salt
- Future studies could compare acceptance of low salt and medium salt products (LM) as well as high salt and medium salt products (HM)
- This would allow those consumers preferring optimal added salt to be identified
- Only 14 out of 80 in current study

<table>
<thead>
<tr>
<th>LM</th>
<th>0</th>
<th>+</th>
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<tbody>
<tr>
<td>-</td>
<td>14</td>
<td>42</td>
</tr>
<tr>
<td>0</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>+</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

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Conclusions and Implications

Cluster Analysis, friedman ANOVA and Wilcoxon Signed Rank Test identified 0.47% added salt as optimum.

Such predictive models may help food manufacturers:
  • reduce salt content effectively (& cost efficiently);
  • enhance product positioning strategies.

Further work is required to validate the model for a range of product types.