A NEW REPRESENTATION OF MULTIDIMENSIONAL SALAMI DATA USING THE BIPLOT GRAPHICAL DISPLAY

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BACKGROUND

In Switzerland, processing conditions as well as non-meat ingredients and additives for the production of Swiss dry-cured salami vary among the different manufacturers leading to different product characteristics and quality attributes. In order to determine of how different these product characteristics may be, several parameters have to be evaluated.
Apart from measuring, an interpretation of the multidimensional data has to be performed. The use of univariate statistical techniques like ANOVA does not help to give a global understanding of the data, therefore multivariate statistical tools have to be used. Though there exist several multivariate statistical techniques, they have rarely been used in the study of dry-cured sausages (Dellaglio et al., 1996). To our knowledge, the following biplot is the first to be applied in the field of fermented meat products.

OBJECTIVES

The aim of the present study was to show the relative chemical composition of Swiss and Italian dry-cured salami, their multivariate variability and their correlations.
Multidimensional interactions between chemical parameters, between different salamis, as well as between chemical parameters and different salamis were to be elucidated.

METHODS

A Milano type salami from each of 9 Swiss and 2 Italian manufacturers was obtained at four time points within 10 weeks. They were delivered either directly by the manufacturers or, in the case of Italian salamis, by the butcher's center in Zurich.
Salamis were aged ready-for-sale. Their mean weight was 0.935 ± 0.347 kg, their mean diameter was 6.1 ± 0.7 cm and their mean length was 31.8 ± 7.7 cm (n=44). Swiss samples were labelled numerically. A number was assigned to each manufacturer (1 to 9) remaining the same for all four samples. Italian samples were labelled the same way but alphanumeric characters (a,b) were used instead of numbers.

Several chemical parameters were analyzed in each sample by using appropriate analytical methods. A stepwise discriminant analysis using the statistical software of SAS (1987) showed that the combination of the following 14 parameters gave the best discrimination between the 11 manufacturers. These parameters were: total nitrogen, crude ash, chloride, pH, L-lactic acid, glucose, nitrates, total pigments, phospholipids, saturated fatty acids, monounsaturated fatty acids, total fatty acids, nitrogen soluble in sodiumdodecylsulfate (SDS) and nitrogen insoluble in SDS.
Based on these 14 parameters and the respective analytical data of all samples, a biplot was performed using the statistical software S-PLUS for Windows (1993).

RESULTS AND DISCUSSION

Figure 1 shows the biplot of the multidimensional salami data. Based on principal component analysis, both the chemical parameters and the multivariate data of individual samples are summarized in this two-dimensional graphical display accounting for 59.2% of the original variability.
The chemical parameters are represented by vectors and the multivariate data by points (Gower & Hand, 1996; Cox et al., 1986). The chemical parameters are standardized and their representation in the two-dimensional space is indicated by solid lines constituting a part of each vector. The longer the solid line, the better the representation of the chemical parameter and the more reliable any interpretation. Correlations between chemical parameters are expressed by angles between the corresponding vectors.

Looking at Figure 1, a rather poor representation of the chemical parameter total pigments can be observed. Any interpretation concerning this parameter will thus be vague.
Concerning the multidimensional interactions between chemical parameters, three major groups of parameters forming small angles with each other and thus being positively correlated can be recognized, e.g. the three parameters of fatty acids. Within the parameter groups, subgroups can be seen, e.g. L-lactic acid and glucose.

Besides the groups of positively correlated parameters, parameters forming angles of about 180° with each other can also be recognized. These parameters are negatively correlated, e.g. pH is negatively correlated with glucose and L-lactic acid, indicating the higher the pH, the lower the amount of glucose and L-lactic acid.

Regarding the location of the different salamis, the plot shows almost clearly divided groups of salamis from the same producer. Salamis being close together indicate a similar chemical composition, e.g. both groups of Italian salamis. Besides, multivariate outliers can easily be identified.
Outlining the multidimensional interactions between the chemical parameters and the different salamis, it can be inferred that certain groups of salamis have a higher concentration of certain parameters than others. These salamis are closer to the respective vectors and have a longer distance on these vectors to the origin, e.g. salamis from producer 7 have a higher content of fatty acids than salamis from producer 2. Salami 1 being located close to the origin of the plot, represents an "average" salami. Explanations for multivariate outliers like salami 2 at the top, can be given, too. This salami contains high amounts of nitrates, low amounts of fatty acids, etc. compared to the other salamis.

CONCLUSIONS

The biplot multivariate analysis provides a two-dimensional display of the chemical parameters and all the salami data. Multidimensional informations and interactions are visible and, in addition to significance tests, a global view of the complex multivariate data is possible. Concerning the relative chemical composition of Swiss and Italian dry-cured salami, their multivariate variability and their correlations were shown. All multidimensional interactions can now be explained and interpreted by knowing the technological and biochemical processes occuring during salami manufacturing.

PERTINENT LITERATURE

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DATA

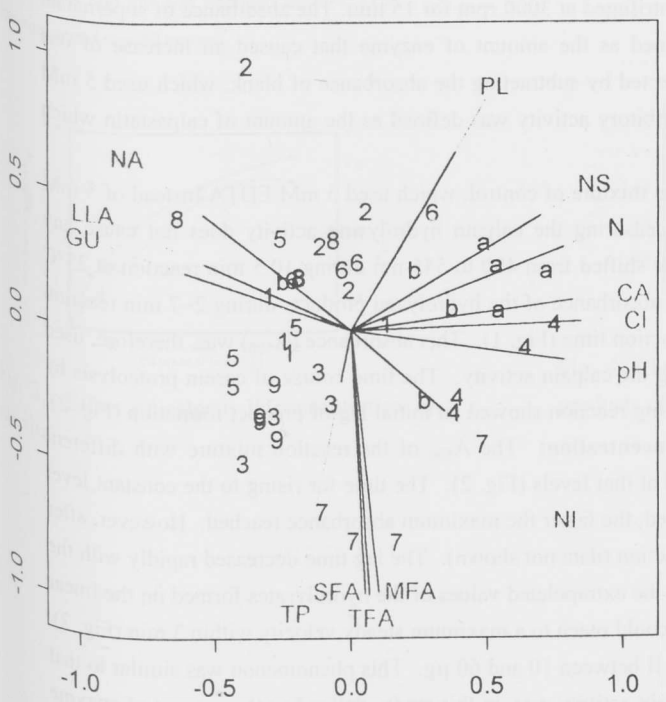

Fig. 1: Biplot of the Multidimensional Chemical Data of 36 Swiss and 8 Italian Dry-Cured Salamis. Analysis Based on the Correlation Matrix. Goodness of Fit: 0.592.

PARAMETER	
N	Total Nitrogen
CA	Crude Ash
Cl	Chloride
pH	pH
LLA	L-Lactic Acid
GU	Glucose
NA	Nitrates
TP	Total Pigments
PL	Phospholipids
SFA	Saturated Fatty Acids
MFA	Monounsaturated Fatty Acids
TFA	Total Fatty Acids
NS	Nitrogen Soluble in SDS
NI	Nitrogen Insoluble in SDS

NUMBER	
1 to 9	Swiss Salami
LETTER	
a and b	Italian Salami