

Flavour profiling of apple vermouth using descriptive analysis technique

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Abstract

Flavour profiling of apple vermouth of different treatments has been evaluated by descriptive analysis. A set of 45 different attributes were used in the experiment. The list of descriptors, concentration of standards and the details of technique has also been described. Based on the flavour profiling, the principal component analysis (PCA) separated the vermouths into groups having vermouths with less than or more than 15% alcohol. PCA was applied to the means of flavour scores generated from flavour profiling. All attributes analyzed across 12 vermouths and the eigen analysis showed that the data were three dimensional. The first 3 PCs accounted for the highest variation, with 62.5, 16.5 and 5.6% out of total of 84.5% variation. The PCA has successfully separated the vermouths with 18% alcohol from 12 or 15% alcohol showing the differences in flavour profile of these products due to ethanol content. The first PC was defined by astringency, ethyl alcohol, phenolic, amyl alcohol, like plum, grape, apple, apricot, cucumbers, black currant, berry, rose, acetic acid, synthetic, green/unripe, salty, lactic, sulphury and spicy while ethyl acetate, SO₂, allspice, musty, cabbage, earthy, sweaty, vinegary, citrus and raisin defined weakly this component. The 2nd PC was defined by acetaldehyde, caramel, sour, fatty acid, rubbery and bitter while metallic taste, sharp, mushroom and yeasty flavours contributed weakly to the 2nd PC. The vermouth of group 1 and 3-9 have been separated from others, based on their richness in apple like, plum like, amyl alcohol, apricot like, ethyl acetate, astringency and phenolic descriptors while these wines were not intense for citrus like, grape like, lactic, cucumbers, black currant, berry like, green/unripe, salty, soapy, sulphury and vinegary descriptors. Vermouth of 10-12 defined by 2nd PC with flavour tones of acetaldehyde and caramel correlated highly with this PC while these were related weakly with sour, fatty acid, bitter, rubbery and these attributes have been highly related with vermouth of treatment 12. The sugar concentration must have affected other parameters important in sensory qualities such as bitterness. It is concluded that the descriptors described here can characterize apple vermouth of different quality attribute. Descriptive analysis along with PCA could be used for characterizing the product with respect to flavour and as a tool for further improvement in the quality of the product.

Keywords: Flavour profiling, Descriptive analysis, Sensory analysis, Apple vermouth, Principal component analysis.

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contents⁶. Sweet vermouth with 15% ethanol was found to be the best product. Method of preparation, physico-chemical characteristics and qualities of the apple vermouth has also been reported⁷.

Flavour of the products like wine is of utmost significance and is one of the quality parameter of its evaluation. The flavour can be evaluated by chemical and sensory evaluation methods. Descriptive methods of sensory evaluation are applied frequently to determine the acceptability of this important quality aspect of alcoholic beverages. To analyse flavour profile, the technique of descriptive analysis has been applied to a variety of beverages, including wine cider and apple wine and beer⁸⁻¹². Wu *et al* evaluated 86 descriptors used to characterize the wine and found 33 having the greatest meanings¹³. Similarly, 27 descriptors have been used for red wine and 6 for white wine evaluation. Williams has reviewed the various components of the wines that contributed to the flavour such as cultivars of grapes, the condition of fruit, fermentation and post-fermentation treatments¹⁰. Apple juice essence had been described by a panel using 18 terms, including pungent, grass-like, pomace like, solvent like, floral, etherish, almond like, cooked apple like, alcoholic, fusel oil like, heavy, rancid, oily, soapy, stuffy

Introduction

Aperitif wines known as 'Vermouth', compounded from grape wines by adding mixture of herbs and spices or their extract, are quite popular in European countries and USA and are produced commercially in USSR and

Poland¹⁻⁴. A new product 'Mango-Vermouth' with a suitable recipe has been developed with high acceptability⁵. Joshi *et al*⁶ prepared plum vermouth of commercial acceptability and found that addition of spices/herbal extract increased the total phenols, aldehyde and ester

and rotten¹³⁻¹⁶. Sourness and astringency, syrupiness and body, mustiness aroma, fruitiness, lightness and sweetness were the descriptors which differentiated the sensory qualities of apple juice aroma in different cultivars¹⁷. The data from flavour profile techniques could be subjected to the analysis by multivariate analysis such as Principal Component Analysis (PCA) and the wines could easily be grouped that enables to analyze observed values of a set of continuous variables for a set of experimental units in order to build new variables called PC, representing the direction of great variability. The PCA gives the pictorial representation. Techniques used in flavour profiling of wines have also been reviewed¹⁰. Noble and Shannon characterized Zinfandel wines by flavour profiling techniques¹⁸. The PCA was successfully employed to determine the extent and significance of differences detected using descriptive analysis technique in the fermented apple wines using different sources of fermentation including natural source of fermentation and commercial wine yeasts¹¹. In this communication, application of the descriptive analytical techniques has been used to evaluate apple vermouth, prepared by using different treatments.

Material and Methods

The samples of apple vermouth of various treatments were prepared as reported earlier and briefly described here⁷. Vermouths of 3 levels of alcohol (12, 15 and 18%) were prepared. Each alcohol level had either 4 or 8% sugar content. Different combinations of products were prepared having 2.5 or 5% spices extracts in each sugar and alcohol level. Spices and herbal extracts were

prepared in the similar manner as for plum and sand pear vermouth^{6,19}. The only difference was of the strength of spices extract prepared. It was made in the double strength than that made for plum and sand pear so that lower quantity of extract could be used and effect of dilution is eliminated.

Flavour profiling

For flavour profiling of product, 'Descriptive Analysis' technique was followed as detailed earlier^{20,21}. The judges were asked to give appropriateness of different terms called as 'descriptors' and

give scores (1-9) depending upon the intensity of flavour tested, in comparison to the standard whose intensity was rated to be the highest with score of 9. Standards for each descriptor were provided to the judges. Procedure of selection of judges, terms selection, determining significance, analysis of variances were the same as described earlier. A list of 45 descriptors used and the standards made available is given in Table 1. Discussion during these evaluations was allowed in the familiarizing session only.

Table 1: List of descriptors, standards and summary of analysis of variance* of apple wines fermented by various fermentation sources

No.	Descriptor	Standard	Mean
1.	Sharp	Acetic acid (1%)	2.33
2.	Vinegary	Vinegar (25 time diluted)	1.79
3.	Acetic	Acetic acid (15 µl/100ml)	2.33
4.	Lactic	Sauerkraut liquid (few ml)	2.71
5.	SO ₂	KMS (0.5% soln)	3.09
6.	Acetaldehyde	Acetaldehyde (100 µl/100ml)	1.71
7.	Ethyl alcohol	Ethyl alcohol (8%)	5.83
8.	Amyl alcoholic	75ml/100ml or amyl alcohol	2.25
9.	Ethyl acetate	10 µl/100 ml of ethyl acetate	2.96
10.	Fusel alcoholic	10 µl/100 ml of methyl propanol	2.42
11.	Black currant	Black currant jam	2.38
12.	Berry like	Strawberry essence	1.50
13.	Plum like	Plum pulp	5.83
14.	Apple like	Apple juice concentrate diluted (1:6)	1.50
15.	Grape like	A few fruits of grape	2.04
16.	Citrus like	A few pieces of orange peel	1.04
17.	Apricot like	Apricot flavour	2.38
18.	Green/unripe	Green grass/green olives	1.49
19.	Cucumber like	A piece of fresh cucumber	1.88
20.	Vegetable like	A few pieces of cabbage	1.71
21.	Rose like	Petal of rose	2.58

No.	Descriptor	Standard	Mean
22.	Metallic	Sodium carbonate (1% soln)	3.08
23.	Musty	A wooden cork	2.50
24.	Earthy	0.5% Bentonite in 10ml water	2.88
25.	Spicy (black pepper)	Pieces of black pepper	6.79
26.	Allspicy	Mixture of spices (25 times diluted)	4.50
27.	Spicy/clove	A few pieces of cloves	3.92
28.	Synthetic	Vanilla flavour (25 times diluted)	2.17
29.	Caramel	Heated 65% sugar solution	2.50
30.	Sweety	Sugar solution (1%)	4.33
31.	Burnt	Burnt sugar	2.04
32.	Raisin	Few pieces of raisin	2.33
33.	Yeasty	Fermented must (1 g sediment)	2.33
34.	Lactic	Curd	2.42
35.	Mushroom	Few pieces of mushroom	1.08
36.	Sulphury	One hard boiled egg	2.08
37.	Cabbage	Few pieces of cabbage	1.42
38.	Rubbery	Rubber piece boiled in water	2.18
39.	Astringent	Few pieces of Aonla	5.67
40.	Phenolic	100mg/1 soln. of tannic acid	2.42
41.	Sour	0.8% soln. of citric acid	3.83
42.	Fatty	Fat (butter) oxidized	2.00
43.	Bitter	Tea leaves extract	4.73
44.	Salty	1% common salt solution	1.32
45.	Soapy	5g block of unperfumed soap	1.95

Results and Discussion

The mean results (Table 1) of flavour descriptor show that overall there were only a few descriptors like sulphur dioxide, ethyl alcohol, plum like, spicy (Black pepper), all spicy, spice like (colour), sweety, astringency, sour and bitter whose score were more than 3 and can be perceived and detected strongly compared to the standards. Most of others like sharp, acetic, lactic, acetaldehyde, amyl alcohol, ethyl acetate, fusel alcoholic, black current, apple, grape, apricot, rose like, musty, synthetic, caramel, burnt, yeasty, lactic acid, sulphury, rubbery and phenolics were detectable. Remaining descriptors were either on the threshold of detection or just perceivable. These flavour descriptors and their strength in the vermouths is understandable as vermouth is a fortified wine and flavouring is done with spices and herbal extract. The just detectable level of these flavour attributes might be the consequence of dominance of other flavour notes described earlier.

Spider web diagram (Fig.1) has shown characteristics differences between various treatments. The flavour differences between the treatments were quite contrasting for the bitter, sour, phenolics, astringency, sweety, sharp, ethyl alcohol and plum like. The results also characterize the major flavour characteristics of vermouth of different treatments like vermouth having 12% alcohol was less bitter, more astringency, more sweety, higher plum like, more ethyl alcoholic, lesser sour, regent low phenolics less sulphur dioxide, flavour aspects related with spices attributes have been merged into one. The different attributes related with fruity aspects though detectable were

Statistical analysis of data

Depending upon the requirement of the experiments, the statistical analysis of the data was carried out. The mean scores of the treatments were plotted as spider-web diagram to compare the differences between all the treatments of vermouth. The data of flavour was first assessed by the analysis of variance (RBD) as per standard practices used for the analysis of this type of data¹¹. Principal Component Analysis (PCA) was performed on the correlation matrix generated from means of sensory qualities of apple

vermouth. The means were used for analysis by principal component as per instructions given for this computer package, PCA.BAS. Various descriptors, treatments and the scores constituted the data²². The output was obtained in the form of principal components (first three), correlation coefficients, matrix and eigen-vectors. The analysis was performed without rotation. The interpretation of data from PCA was made by plotting Principal Components 1 vs 2 or 1 vs 3 and attributes loading as vectors along with treatments, simultaneously.

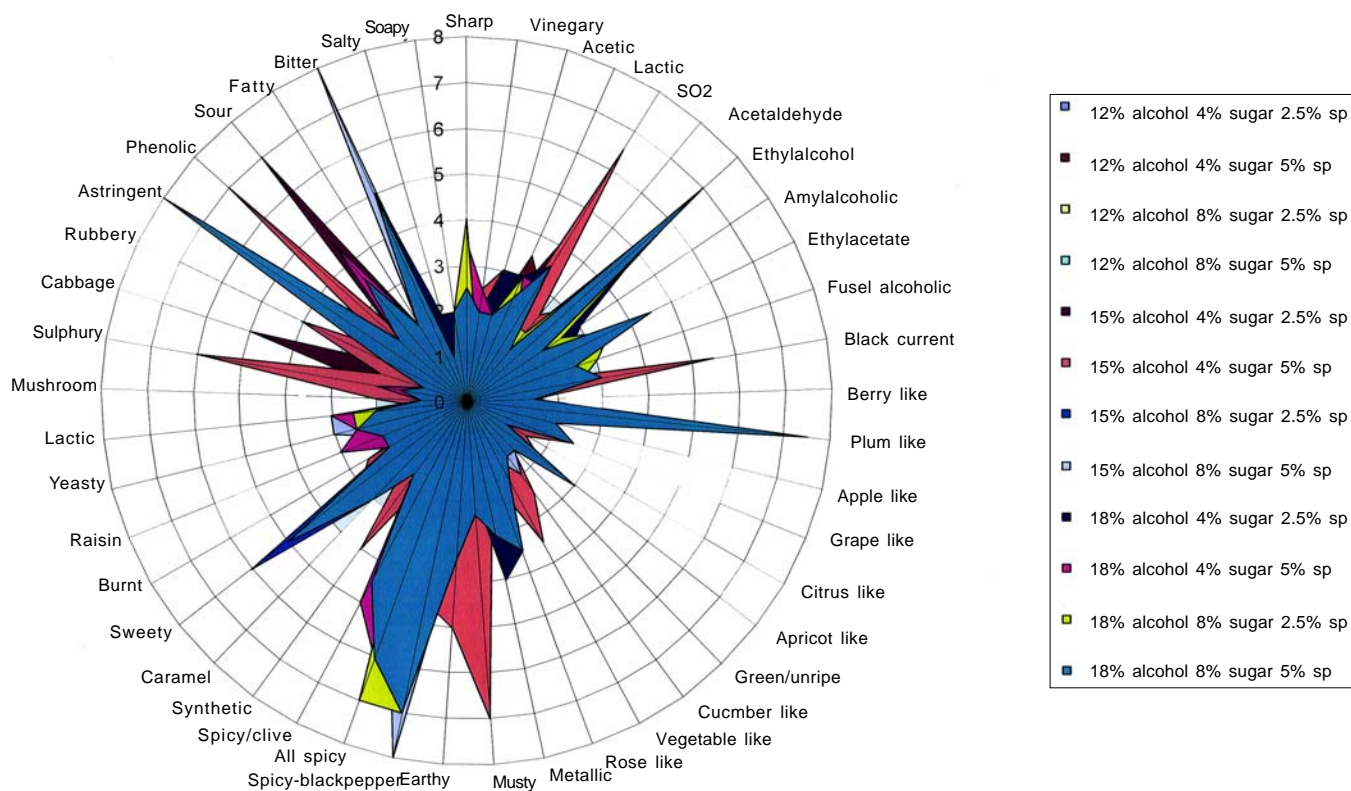


Fig. 1: Spider web diagram of apple vermouth of different treatments

clearly dominated by the notes like sour, both astringent spicy imparted by the spices and herbal extract. Flavour profiling of apple wine reported earlier show that overall there were no significant differences between the treatments for the terms, viz. berry like, earthy, spicy/clove and sulphury¹¹. The judges scored all the attributes significant except for the terms sharp, lactic, berry like, earthy, burnt and sulphury. All the descriptors except for acetaldehyde, berry, apple and vegetable like, sulphury, cabbage and soapy were significant for apple wines of various treatments.

The PCA of the flavour profiling data of apple vermouth using sets of

different attributes was carried out. The attributes were plotted as vectors and the wines of various treatments simultaneously on the first two PC components. In one set, 45 attributes were analyzed across 12 vermouths and the eigen analysis (Table 2) showed that the data were three dimensional. The first three PCs accounted for the highest variation, with 62.5, 16.5 and 5.6% out of total of 84.5% variation that could be accounted for. As per the Kaiser criterion, the first two PCs were the most important and therefore, the interpretation shall be limited to these PCs only. A plan projection of PC-1 against PC-2 of vermouths of various treatments without plotting

attributes is shown in Fig. 2. It is clear that PCA has successfully separated the vermouths with 18 % alcohol from 12 or 15 % alcohol and the differences in flavour profile of these products.

It is also evident from Fig. 3 that the PC-1 was defined by astringency, ethyl alcohol, phenolic, amyl alcohol, berry, plum, apple and apricot like, acetic acid, synthetic, green/unripe, like cucumbers, black currant, salty, lactic, sulphury and spicy while ethyl acetate, SO₂, rose like, allspice, musty, cabbage, earthy, sweaty, vinegary, citrus, grape like and raisin defined weakly this component. The PC-2 was defined by acetaldehyde, caramel, sour, fatty acid, rubbery and bitter while

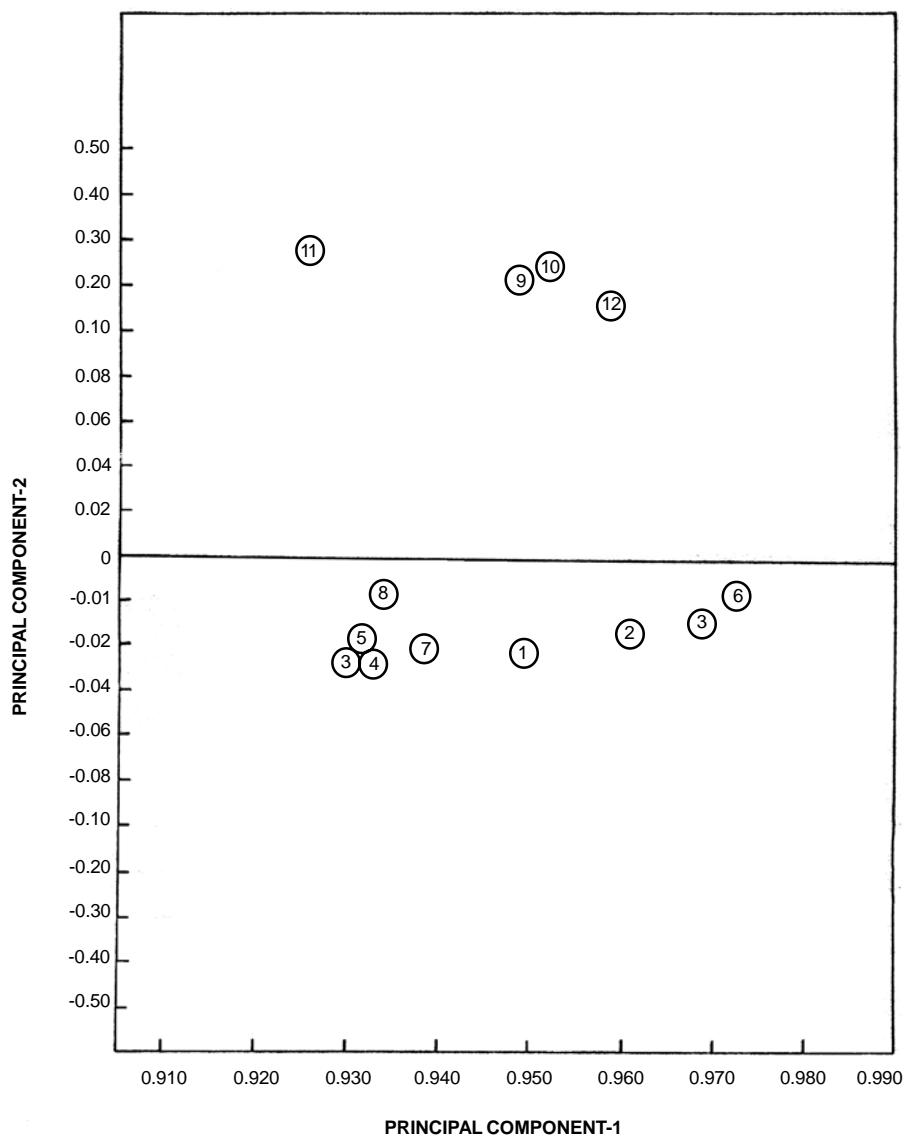


Fig.2: Plane projection of flavour profiling of apple vermouth as defined by two principal components based upon 45 attributes

(1. 12%Eth+4%Sug+2.5%Sp. Ext., 2. 12%Eth+4%Sug+5%Sp. Ext., 3. 12%Eth+8%Sug+2.5%Sp. Ext., 4. 12%Eth+8%Sug+5%Sp. Ext., 5. 15%Eth+4%Sug+2.5%Sp. Ext., 6. 15%Eth+4%Sug+5.0%Sp. Ext., 7. 15%Eth+8%Sug+2.5%Sp. Ext., 8. 15%Eth+8%Sug+5.0%Sp. Ext., 9. 18%Eth+4%Sug+2.5%Sp. Ext., 10. 18%Eth+4%Sug+5%Sp. Ext., 11. 18%Eth+8%Sug+2.5%Sp. Ext., 12. 18%Eth+8%Sug+5%Sp. Ext.). Eth =Ethanol, Sug =Sugar, Sp Ext=Spices Extract.

metallic taste, sharp, mushroom and yeasty flavours contributed weakly to the PC-2. It is also clear that vermouth of group 1, & 3-9 have been separated from

others, based upon their richness in apple, plum and apricot like, amyl alcohol, ethyl acetate, astringency and phenolic descriptors while these wines were not

Table 2: Principal Components Analysis output of flavour profiling data of apple vermouth using 45 attributes

Eigen values	Per cent of trace	Accumulated % of trace
7.488	62.4	62.4
1.984	16.5	78.9
0.669	5.6	84.5
0.495	4.1	88.6
0.376	3.1	91.8
0.284	2.4	94.1
0.255	2.1	96.3
0.143	1.2	97.5
0.120	1.0	98.5
0.100	0.8	99.3
0.052	0.4	99.7
0.034	0.3	100.0

intense for citrus and grape like, lactic, cucumbers, black currant, berry like, green/unripe, salty, soapy, sulphury and vinegary descriptors. Vermouth of 10 to 12, defined by PC-2 with flavour tones of acetaldehyde and caramel correlated highly with this PC while these were related weakly with sour, fatty acid, bitter, rubbery and these attributes have been highly related with vermouth of treatment 12. The caramel like flavour tones of wine could probably be due to more sugar content and less acidity. According to Wijeyaratna *et al*²³ cloves, cinnamon, ingurupiyali, ginger, cardamom, nutmeg and mace improved the flavour, but cinnamon, cloves and cardamom provided the most preferred flavour contribution individually as well in pairs of aqueous ethanol (15%).

Some interaction between three parameters, viz. alcohol levels, spices

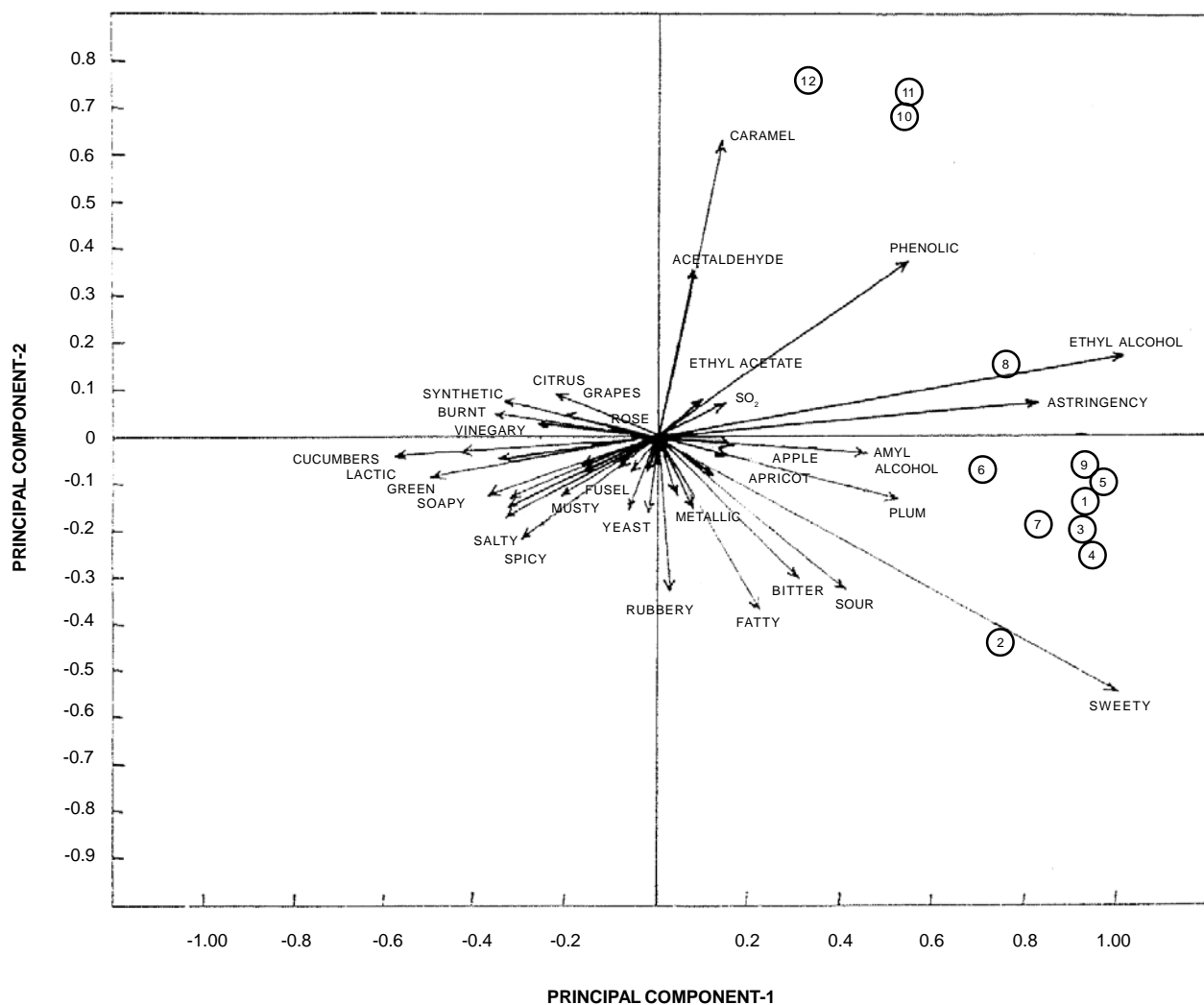


Fig.3: Projection of flavour profiling data of apple vermouth of various treatments in planes defined by principal components 1 and 2 (Numbers in circles represent the treatment code)

(1. 12%Eth+4%Sug+2.5%Sp. Ext., 2. 12%Eth+4%Sug+5%Sp. Ext., 3. 12%Eth+8%Sug+2.5%Sp. Ext., 4. 12%Eth+8%Sug+5%Sp. Ext., 5. 15%Eth+4%Sug+2.5%Sp. Ext., 6. 15%Eth+4%Sug+5.0%Sp. Ext., 7. 15%Eth+8%Sug+2.5%Sp. Ext., 8. 15%Eth+8%Sug+5.0%Sp. Ext., 9. 18%Eth+4%Sug+2.5%Sp. Ext., 10. 18%Eth+4%Sug+5%SP Ext., 11. 18%Eth+8%Sug+2.5%Sp. Ext., 12. 18%Eth+8%Sug+5%Sp. Ext.)

extract and sugar level was also observed as grouping along these lines did not take place clearly. The sugar concentration must have affected other parameters important in sensory qualities such as bitterness as demonstrated in earlier studies²⁴⁻²⁶. Similarly, increase in viscosity in product

with 8% sugar and a decrease in perceived bitterness of vermouth must have taken place as observed earlier²⁷. Petrova *et al* developed a bitter aperitif wine, with 21% alcohol, sugar 240-250g/l and an infusion of bitter herbs such as centaury [*Erythraea centaurium* (Linn.)

Borkh.] and coriander (*Coriandrum sativum* Linn.), rosemary (*Rosamarinus officinalis* Linn.) and nutmeg (*Myristica fragrans* Houtt.) infused in 50% alcohol and water solution for 2-3 days at a ratio of 73, 12, 2 and 3%, respectively, having

characteristic bitter odour and flavour which could be used in the cocktails or with carbonated water²⁸.

Conclusion

Based on the flavour profiling using 45 attributes, the PCA separated the vermouths into groups having less than or more than 15% per cent alcohol. One of the groups was characterized by the intensity of apple, plum, amylalcohol, apricot, ethyl acetate, astringency and phenolic flavours. The other group had more acetaldehyde, sour, fatty acid, bitter, rubbery and caramel flavour tones. The flavour profiling of apple vermouth could throw quite useful information on the quality of wine in itself and in conjunction with chemical characteristics.

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