

# Relationships between the Maximum Temperature Reached in the Smoke Generation Processes from *Vitis vinifera* L. Shoot Sawdust and Composition of the Aqueous Smoke Flavoring Preparations Obtained

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Several aqueous flavoring preparations were obtained from *Vitis vinifera* L. shoot sawdust; all parameters of the smoke generation were kept constant except the rate and length of heating, as well as the maximum temperature reached in the process. The acidity and the composition of the aqueous smoke flavoring preparations obtained were determined, the latter by means of gas chromatography/mass spectrometry and gas chromatography with flame ionization detection. Relationships were found only between the maximum temperatures reached in the pyrolytic processes and the compositions of the smoke flavoring preparations. An increase in the maximum temperature reached in the smoke generation produces an increase in the acidity and in the yield of the flavor components only if the temperature does not exceed certain values. The fitting of the data of the maximum temperature reached in the process and the yield of several compounds, or acidity data of the flavoring preparations, to polynomial regressions gives equations useful for predicting the acidity and the yield optimum of each component.

**Keywords:** *Vitis vinifera* L. shoot sawdust; smoke generation; temperature; yield; composition; smoke flavorings; relationships; organoleptic properties

## INTRODUCTION

In smoke generation several parameters influence the yield of smoke, its composition, and therefore its organoleptic properties (Maga, 1988; Girard, 1991). These parameters are the nature of the wood, the temperature of the process, the amount of oxygen present during the smoke generation, the moisture content of the wood, and the wood particle size. The same parameters must also be taken into account when smoke flavoring preparations are obtained. In spite of that, the influence of each one of them has not been studied in depth.

Among these factors, temperature has been considered as one of the most important (Maga, 1988). However, some of the results of several studies of the influence of this parameter on the yield of several groups of flavor compounds are contradictory. Some authors found that the highest yields in acids and carbonyl and phenol derivatives were obtained when the pyrolysis was carried out at approximately 600 °C (Hamm and Potthast, 1976; Baltés et al., 1981). This temperature has also been considered by other authors as causing the highest yield in phenol derivatives (Toth, 1980a,b). An increase in the yield of pyrazines has also been observed when the degradation of hickory sawdust was carried out at 450 °C instead of at 290 °C (Maga and Chen, 1985). However, results of other studies are not apparently in agreement with those mentioned above (Simon et al., 1966; Porter et al., 1965). On the other hand, independently of the yield and smoke composition, other authors have pointed out that the best organoleptic properties of the smoke are obtained when the smoldering temperature is 400 °C (Daun, 1972; Girard, 1991).

Furthermore, it must be noted that the pyrolytic process does not occur at a constant temperature, and it is well-known that, during thermal degradation of

wood, an endothermic process of water releasing is produced (120–150 °C) and that exothermic reactions of hemicellulose (200–250 °C), cellulose (280–320 °C), and lignin (400 °C) degradation are produced at different temperatures.

Given our interest in the usefulness of wood otherwise wasted annually, such as the prunings of fruit trees, for obtaining smoke flavoring preparations, in this paper the compositions of some aqueous smoke flavoring preparations obtained from *Vitis vinifera* L. shoot sawdust, at different temperatures, are reported for the first time. During the smoke generation in the various runs, the sawdust particle size, the amount of oxygen present in the process, and the moisture content of the wood were kept constant to determine the influence of the rate and length of heating as well as of the maximum temperature reached on the acidity and on the yield of the components of the smoke flavoring preparations. Relationships between the maximum temperature reached in the smoke generation and the composition of the aqueous smoke flavoring preparations obtained were tested.

## MATERIALS AND METHODS

The *V. vinifera* L. shoots from the annual pruning were collected in the winter of 1993. They were air-dried for 6 months and ground in a Restch DR 15/40 mill. Only sawdust particles smaller than 2 mm<sup>2</sup> were used in the smoke generation. The process was carried out in a laboratory round-bottom flask smoke generator made of quartz. The pyrolysis was started with the use of a rheostat-controlled heating mantle. The heating mantle surface is able to reach, in 30 min, 170 or 370 °C, at power 1 or 3, respectively. All parameters that influence the smoke generation process were kept constant in the several runs, except the rate and the length of heating.

Five experiments of smoke generation were performed. Experiments 2D, 17N, and 17O, were carried out by keeping

the heating mantle at power 1 for 32, 38, and 42 min, respectively, and then at power 3 for 26 min in the 2D and 17N runs and for 13 min in the 17O run. In the runs 9N and 12J there was no preheating period and the heating mantle was switched on at power 3 for 21 min in the 9N run and for 40 min in the 12J run. The temperature was measured with a Crison thermometer 639K positioned in the center of the charge of sawdust.

The smoke resulting from 100 g of sawdust was filtered by means of a glass wool filter and collected in 150 mL of distilled water. The aqueous liquid smoke obtained was again filtered through a paper filter. The acidity of each smoke flavoring was determined by titration with 0.01 N NaOH.

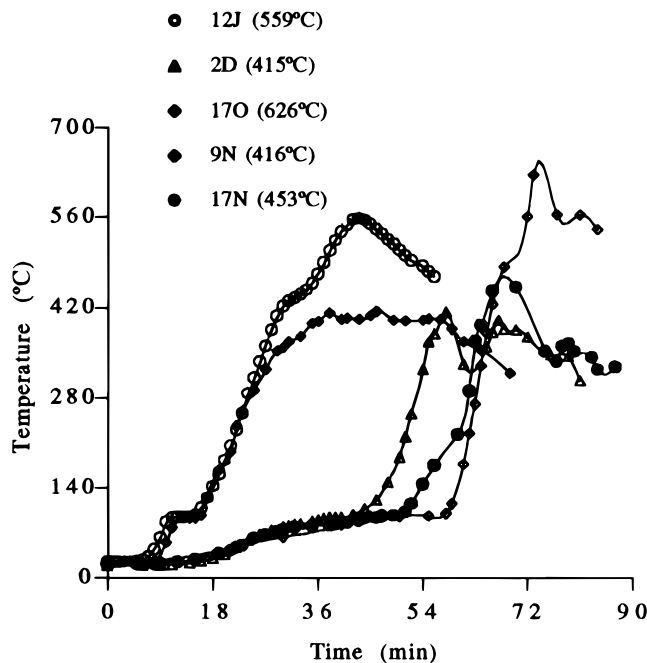
The flavoring fractions of the aqueous preparations were isolated by liquid-liquid extraction using  $\text{CH}_2\text{Cl}_2$  as solvent. This organic solvent was selected for its high effectiveness in extracting polycyclic aromatic compounds (Guillén et al., 1991; Guillén, 1994) and aromatic compounds in general.

The identification of the smoke components was carried out by gas chromatography/mass spectrometry (GC/MS) and by using standards. The GC/MS study was performed using a Hewlett-Packard chromatograph, Model 5890 Series II, equipped with a mass spectrometer selective detector 5971, and a Hewlett-Packard Vectra 486/66U computer. A fused-silica capillary column (30 m long and 0.25 mm in diameter), coated with a nonpolar stationary phase (Hewlett-Packard 5, cross-linked 5% phenyl methyl silicone) was used. The temperature program began at 50 °C (0.5 min) with an increase of 2 °C/min to 280 °C (15 min), and He was used as the gas carrier. Injector and detector temperatures were 250 and 280 °C, respectively. The injection technique used was splitless. The injection volume was 1  $\mu\text{L}$ . Mass spectra were recorded at an ionization energy of 70 eV. Components were identified by their mass spectra, by comparing their mass spectra with those in a commercial library (Wiley138k, Mass Spectral Database, 1990), and in many cases using standards, as in previous studies (Guillén and Manzanos, 1994, 1996; Guillén et al., 1995).

The quantification of the components was accomplished with a Hewlett-Packard Model 5890 Series II gas chromatograph equipped with a flame ionization detector (FID) and a Hewlett-Packard 3395 integrator. A fused-silica capillary column (30 m long  $\times$  0.32 mm internal diameter), coated with a nonpolar stationary phase (Hewlett-Packard 5, cross-linked 5% phenyl methyl silicone), was used. The gas chromatographic conditions were the same as in the GC/MS study. The quantification was carried out using external standards. To this aim response factors of all compounds asterisked in Table 1 were determined as before (Blanco et al., 1992). For the quantification of compounds not available commercially, response factors of compounds of similar nature were used. In all cases linear response was considered. Standard compounds were available from Aldrich, Fluka, and Sigma.

## RESULTS AND DISCUSSION

Smoke generation was carried out at different heating rates in each experiment. Figure 1 shows the temperature reached in the center of the charge of sawdust versus time in each experiment of smoke generation. In all cases is observed a more or less long period of time in which, in spite of the heating, the temperature in the center of the sawdust charge does not exceed 100 °C, indicating that at this temperature there is an endothermic process. Afterward, the temperature increases, reaching different maximum temperatures in each experiment. The differences in the rate and length of heating among several runs result in the sawdust charge remaining at high temperature for more or less time, the smoke being produced at higher or slower rate, and the maximum temperature reached being different in each run. The maximum temperatures reached were as follows: run 2D, 415 °C; run 17N, 453 °C; run 17O, 626 °C; run 12J, 559 °C; and run 9N, 416 °C.



**Figure 1.** Temperature reached in the center of sawdust charge versus time in the several smoke generation processes. The maximum temperature reached in each run is given in parentheses.

The smoke produced in each run, after filtration, was collected in distilled water and filtered again. Each aqueous smoke flavoring obtained has a similar gold color and distinctive odor. The acidity of the several flavoring preparations, expressed as number of equivalents obtained from 100 g of sawdust, is given in Table 1. It is evident that, independent of the heating conditions, in general the acidity increases with the temperature until a concrete value for the latter is reached, over which the acidity decreases. This fact could be due to decarboxylation processes at high temperature.

A part of each smoke flavoring preparation was extracted with  $\text{CH}_2\text{Cl}_2$  to identify and quantify its components by means of GC/MS and GC with FID detection techniques. In Table 1 some of the main identified compounds are given together with the content in milligrams of each component in each smoke flavoring preparation, obtained from 100 g of *V. vinifera* L. shoot sawdust. Aldehydes, ketones, diketones, furan and pyran derivatives, esters, and phenol derivatives were identified and quantified. Also, acids such as acetic, propionic, butyric, valeric, isovaleric, levulinic, and others were identified, but they are not present in Table 1 because they elute together with other compounds and their accurate quantification was not possible. However, the acidity data cited above give information for the concentration of the acids in each sample. This is also the reason some compounds (designated with nd in Table 1) were not quantified.

The data in Table 1 are arranged following increasing maximum temperature of the run, independent of the heating conditions of the process. It can be observed that the concentration of each compound, the concentration of the several groups of compounds, and the yield of the overall flavor compounds have rising values as the maximum temperature of the experiment increases until a determined temperature, above which the concentration diminishes, in the same way as observed for the acidity of the flavoring preparations. These results

**Table 1. Maximum Temperature Reached in Each Smoke Generation Experiment Together with the Main Components of the Corresponding Aqueous Smoke Flavoring and Their Content in Milligrams, Obtained from 100 g of *V. vinifera* L. Shoot Sawdust under Different Heating Conditions**

compound	415 °C	416 °C	453 °C	559 °C	626 °C
aldehydes	41.6	60.8	69.3	39.5	23.8
acetaldehyde*	11.6	12.8	16.3	7.3	6.2
propionaldehyde*	nd <sup>a</sup>	nd	nd	nd	nd
isovaleraldehyde*	3.0	2.2	1.9	0.8	0.7
2-ethylbutanal*	27.0	45.8	51.2	31.4	16.9
ketones	261.1	388.8	446.8	348.4	191.2
2-butanone*	nd	nd	nd	nd	nd
3-methylbutan-2-one*	26.7	45.2	44.4	31.7	22.1
2-pentanone*	nd	nd	nd	nd	nd
4-methyl-2-pentanone*	6.0	6.7	8.9	5.0	2.4
2-methyl-3-pentanone*	1.6	2.4	2.3	1.2	0.8
3-methylpentan-2-one*	1.4	2.4	2.2	3.3	0.9
3-hexanone*	11.7	16.1	12.9	nd	7.3
cyclopentanone*	23.1	29.3	37.4	23.1	9.3
4-hydroxy-4-methyl-2-pentanone*	7.8	6.7	15.4	12.12	2.0
1-(acetyloxy)-2-propanone	78.1	141.8	171.0	130.9	66.7
2-methyl-2-cyclopenten-1-one*	27.1	37.8	40.7	34.4	17.7
dimethyl-2-cyclopenten-1-one	9.1	10.6	13.4	8.3	1.9
3-methyl-2-cyclopenten-1-one*	27.9	36.1	38.1	37.2	24.6
dimethyl-2-cyclopenten-1-one (isomer)	13.5	16.7	20.2	17.1	12.4
3,4,5-trimethyl-2-cyclopenten-1-one	19.3	25.8	27.8	31.5	16.3
dimethyl-2-cyclopenten-1-one (isomer)	4.5	5.0	5.4	6.1	3.4
phenyl ethanone*	0.7	1.9	2.2	1.4	1.0
2-nonanone*	2.5	3.7	4.3	5.0	2.3
diketones	88.1	98.6	113.2	117.0	71.9
3-methyl-1,2-cyclopentanedione (cyclotene)*	61.5	67.2	78.1	76.4	47.5
3,5-dimethyl-1,2-cyclopentanedione	5.8	3.1	3.4	3.3	2.2
dimethyl-1,2-cyclopentanedione	4.0	4.9	5.4	10.4	3.8
3-ethyl-1,2-cyclopentanedione	16.7	19.5	23.2	26.9	15.4
5-ethyl-3-methyl-1,2-cyclopentanedione	nd	3.8	3.1	nd	3.0
furan and pyran derivatives	648.9	883.7	946.0	880.6	532.4
2-furancarboxaldehyde (furfural)*	228.1	331.4	356.5	255.6	171.0
2-furanmethanol	tr <sup>b</sup>	tr	tr	tr	tr
5-methyl-2(3 <i>H</i> )-furanone*	23.0	31.3	32.2	26.9	19.2
1-(2-furanyl)ethanone*	12.4	23.1	24.4	26.2	11.6
2(5 <i>H</i> )-furanone ( $\gamma$ -crotonolactone)*	223.4	293.4	309.2	332.2	210.4
dihydro-2(3 <i>H</i> )-furanone	40.9	43.5	49.8	61.2	23.6
5-methyl-2(5 <i>H</i> )-furanone	3.2	4.4	4.6	4.5	3.3
5-methyl-2-furancarboxaldehyde*	17.4	23.4	23.7	23.2	12.4
3-methyl-2(5 <i>H</i> )-furanone*	8.3	4.4	4.8	13.1	2.5
3-hydroxy-5-methyl-2(5 <i>H</i> )-furanone	69.8	98.4	108.8	97.8	54.1
3-hydroxy-2-methyl-4 <i>H</i> -pyran-4-one (maltol)*	15.2	21.1	22.0	27.1	17.5
5-(hydroxymethyl)-2-furancarboxaldehyde*	7.2	9.1	9.9	12.8	6.6
esters	30.2	61.8	66.3	42.9	24.2
ethyl propionate*	nd	10.5	7.1	5.2	3.7
ethyl butyrate*	nd	2.6	5.6	1.6	1.0
methyl pentanoate*	2.9	5.8	4.2	6.3	1.6
ethylene glycol monoacetate*	6.8	16.3	20.3	3.9	2.0
ethyl pentanoate*	1.8	1.5	4.4	1.8	1.2
ethylene glycol diacetate*	18.7	25.1	27.8	24.1	14.7
phenol derivatives	164.7	222.1	235.5	285.1	142.1
phenol*	49.4	66.8	66.9	86.8	45.4
2-methylphenol*	38.2	50.8	55.8	64.7	32.3
3- and 4-methylphenol*	43.1	56.9	61.8	72.7	38.5
2,6-dimethylphenol*	4.5	7.0	7.9	8.8	3.8
2-ethylphenol*	4.1	7.0	6.8	9.5	4.2
2,4- and 2,5-dimethylphenol*	14.1	16.9	18.7	24.1	10.4
4-ethylphenol*	4.7	7.3	7.8	4.1	4.3
2,3-dimethylphenol	6.6	9.4	9.8	14.4	3.1
guaiaicol derivatives	160.6	196.3	231.2	246.3	135.1
2-methoxyphenol (guaiaicol)*	80.1	104.1	121.9	105.9	68.3
4-methyl-2-methoxyphenol*	22.1	29.6	33.0	36.2	20.2
4-ethyl-2-methoxyphenol*	14.3	20.5	23.3	25.8	12.9
4-vinyl-2-methoxyphenol	10.2	12.5	13.0	20.7	9.6
4-(2-propenyl)-2-methoxyphenol (eugenol)*	4.9	4.9	6.5	7.1	3.7
4-propyl-2-methoxyphenol*	1.1	1.9	2.4	4.9	1.0
4-hydroxy-3-methoxybenzaldehyde (vanillin)*	3.6	0.3	3.4	10.1	2.5
4-(1-propenyl)-2-methoxyphenol (isoeugenol)*	4.4	5.1	4.8	5.9	2.3
4-(1-propenyl)-2-methoxyphenol (isoeugenol)*	8.7	9.6	10.8	14.7	7.1
1-(4-hydroxy-3-methoxyphenyl)ethanone*	3.2	2.3	3.8	6.2	2.1
1-(4-hydroxy-3-methoxyphenyl)-2-propanone	8.0	5.6	8.1	8.8	5.2
syringol derivatives	140.1	123.2	163.9	170.7	113.4
2,6-dimethoxyphenol (syringol)*	76.6	70.0	94.4	96.9	64.8
4-methyl-2,6-dimethoxyphenol	14.8	13.4	18.7	17.1	12.5
4-ethyl-2,6-dimethoxyphenol	11.0	10.1	13.6	12.7	9.8

**Table 1 (Continued)**

compound	415 °C	416 °C	453 °C	559 °C	626 °C
4-(2-propenyl)-2,6-dimethoxyphenol*	3.1	3.0	3.8	3.4	2.7
4-propyl-2,6-dimethoxyphenol	1.6	1.9	2.4	2.2	1.5
4-(1-propenyl)-2,6-dimethoxyphenol	1.6	1.8	2.1	2.6	1.5
4-hydroxy-3,5-dimethoxybenzaldehyde*	2.6	2.0	2.6	2.6	1.3
4-(1-propenyl)-2,6-dimethoxyphenol	3.4	5.4	5.0	9.5	5.4
1-(4-hydroxy-3,5-dimethoxyphenyl)ethanone*	7.3	4.7	5.3	5.6	4.6
1-(4-hydroxy-3,5-dimethoxyphenyl)-2-propanone	16.5	9.6	14.1	16.2	8.1
1-(4-hydroxy-3,5-dimethoxyphenyl)-1-propanone	1.7	1.3	1.9	1.9	1.0
pyrocatechol	5.5	5.0	5.5	2.0	3.9
3-methoxypyrocatechol*	57.3	52.3	65.3	68.2	39.5
miscellaneous					
1,4-dimethoxybenzene*	2.1	4.7	4.2	2.6	3.2
2,6-dimethoxytoluene	1.5	2.0	2.0	2.0	1.4
total carbonyl derivatives	1070.0	1493.2	1641.6	1428.5	843.7
total phenol derivatives	528.3	598.7	701.4	772.4	433.8
total content	1601.8	2098.6	2349.3	2205.4	1282.1
acidity (equivalents)	0.0607	0.0557	0.0659	0.0670	0.0564

<sup>a</sup> nd, not determined. <sup>b</sup> tr, trace.

**Table 2. Summary of the Coefficients *a*, *b*, *c*, and *d* and Correlation Coefficients *R* of Equations 1 and 2, Obtained by Fitting Data of the Temperature of the Process, and Acidity, Total Yield, and Yield of Some Compounds and Groups of Compounds (Predicted Temperature *T* at which the Optimum Yield *Y*<sub>max</sub> Is Obtained)**

yield of	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>R</i>	<i>T</i> (°C)	<i>Y</i> <sub>max</sub> (mg)
acidity	-0.2208	0.0011	-1.0901 × 10 <sup>-6</sup>		0.9312	516	0.069
total flavor compounds	-18395.4	83.0271	-0.0825		0.9211	503	2494
total phenol derivatives	-6797.4	29.8110	-0.0291		0.9790	512	837
phenol and alkylphenol derivatives	-2765.9	11.9499	-0.0116		0.9121	515	312
phenol	-772.3	3.3398	-0.0032		0.8744	515	88
2-methylphenol	-642.2	2.7780	-0.0027		0.9308	514	72
guaiacol and guaiacol derivatives	-2323.7	10.1460	-0.0099		0.9657	511	268
guaiacol	-837.9	3.8233	-0.0038		0.8909	503	124
4-methylguaiacol	-334.3	1.4573	-0.0014		0.9255	520	45
4-ethylguaiacol	-274.3	1.1803	-0.0011		0.9236	513	28
syringol and syringol derivatives	-1228.8	5.5063	-0.0054		0.9662	510	175
syringol	-734.6	3.2669	-0.0032		0.9815	514	105
4-methylsyringol	-116.9	0.5332	-0.0005		0.9265	510	19
4-ethylsyringol	-74.3	0.3444	-0.0003		0.9235	512	14
total carbonyl derivatives	-11592.1	53.1671	-0.0533		0.8807	499	1666
ketones	-17752.6	100.0657	-0.1797	1.0483 × 10 <sup>-4</sup>	0.9045	480	469
1-(acetyloxy)-2-propanone	-8909.7	50.0980	-0.0904	5.3246 × 10 <sup>-5</sup>	0.8709	484	198
2-methyl-2-cyclopentenone	-297.6	1.3730	-0.0014		0.9090	494	41
diketones	-876.8	3.9486	-0.0039		0.9814	506	123
cyclotene	-550.7	2.5173	-0.0025		0.9886	504	83
furan and pyran derivatives	-6667.2	30.5640	-0.0305		0.8867	501	990
furfural	-14700.4	85.0800	-0.1576	9.5207 × 10 <sup>-5</sup>	0.8849	471	358
2(5 <i>H</i> )-furanone	-2411.2	10.8171	-0.0106		0.8905	511	348
maltol	-210.8	0.9143	-0.0009		0.8761	521	27
aldehydes	-4065.4	23.6925	-0.0445	2.7388 × 10 <sup>-5</sup>	0.9335	466	70
esters	-3862.9	22.2201	-0.0412	2.4995 × 10 <sup>-5</sup>	0.8131	473	70

are basically in agreement with those of other authors who found, at a determined smoldering temperature, maximum yields of phenol, guaiacol, pyrocatechol, and syringol (Toth, 1980b), or of group of compounds (carbonyl derivatives, phenols, and acids) (Toth, 1980a; Baltes et al., 1981), but are in disagreement with others (Simon et al., 1966; Porter et al., 1965).

Taking into account the results in Table 1, the fitting of the yield *Y* and of the maximum temperature *T* data of the several runs to polynomial equations of second degree, such as

$$Y = a + bT + cT^2 \quad (1)$$

or in some cases of third degree, such as

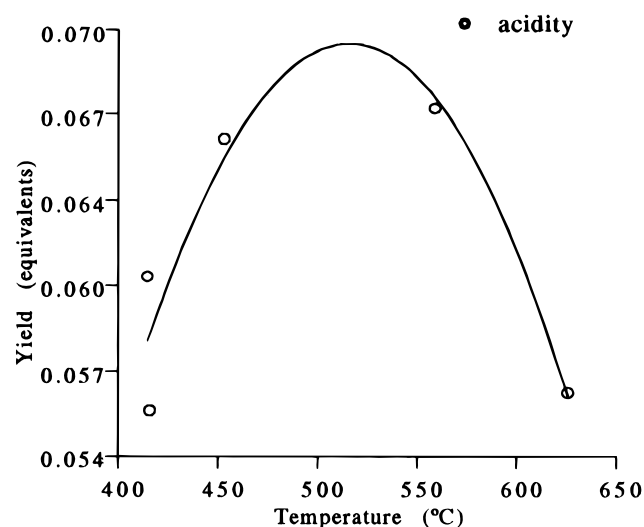
$$Y = a + bT + cT^2 + dT^3 \quad (2)$$

was tested and very high correlation coefficients *R* were obtained. Table 2 gives the coefficients *a*, *b*, *c*, and *d*

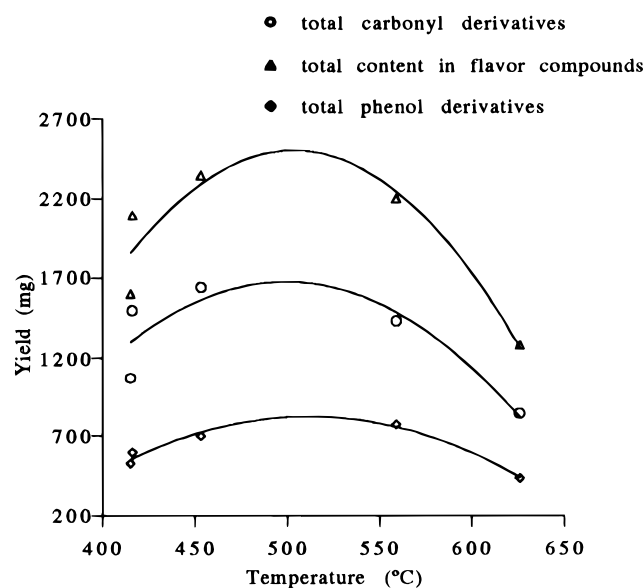
and the correlation coefficients *R* of eqs 1 and 2 corresponding to the fitting of the yield of the overall flavor compounds, or of the several groups of compounds, or of the individual main components, or the acidity values and the maximum temperature data of the different runs. As can be observed from data in Table 1, and coefficients in Table 2, the total yield of flavor compounds is highly dependent on the maximum temperature reached in the smoke generation process.

Between the two large groups of compounds, the yield of carbonyl derivatives is the most affected by this factor and, within this group, the yields of ketones and of furan and pyran derivatives are to a great extent influenced by the maximum temperature of the run; the yield of diketones is less affected. Among carbonyl derivatives the yields of furfural, 1-(acetyloxy)-2-propanone, and 2(5*H*)-furanone are highly influenced by the maximum temperature reached in the run.

The yield of the overall phenol derivatives is also affected to a great extent by the run temperature, and among the different phenolic groups the yield of phenol



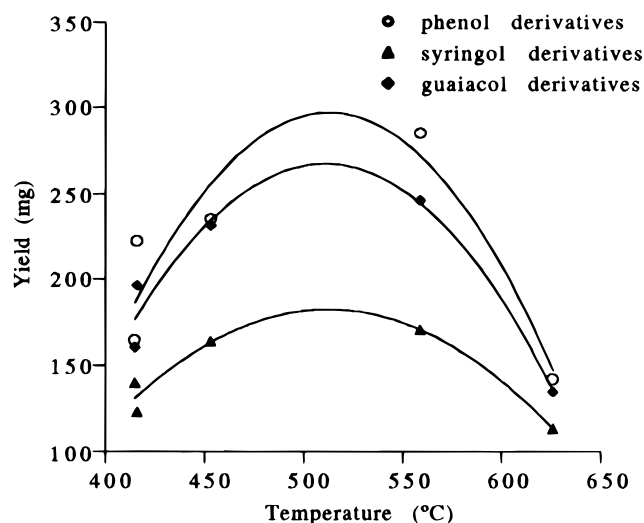
**Figure 2.** Acidity experimental data of the flavoring preparations versus maximum temperature reached in each run; curve line corresponding to eq 1 and coefficients in Table 2.



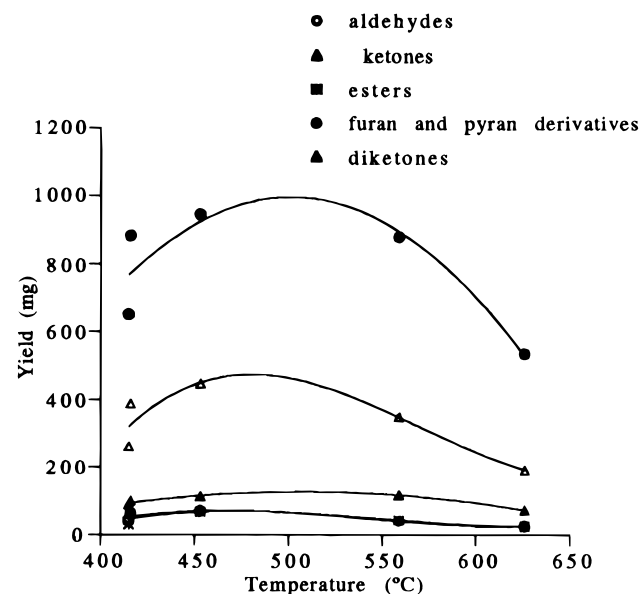
**Figure 3.** Yield experimental data of the total flavor compounds, of the total carbonyl, and of the total phenol derivatives of the flavoring preparations versus maximum temperature reached in each run; curve lines corresponding to eq 1 and coefficients in Table 2.

and guaiacol derivatives is much more influenced than the yield of syringol derivatives.

Figures 2–5 show experimental points and curves corresponding to some equations whose coefficients are in Table 2. Taking into account the values of their correlation coefficients, eqs 1 and 2 can be used for predicting purposes. Assuming  $\delta Y/\delta T = 0$  in eqs 1 and 2, the temperature of the process for the highest yield can be obtained. In Table 2 the maximum temperatures of the process ( $T$ ) to obtain the highest yields ( $Y_{\max}$ ) of the overall flavor compounds, of the different groups of compounds, of some main components, and of acidity are given. In previous studies (Toth, 1980a,b; Baltes et al., 1981), 600 °C has been reported as the smoldering temperature to obtain the highest yield of different groups of compounds (carbonyl and phenol derivatives as well as acids), and of the four phenolic compounds above mentioned. However, our results show that the temperature at which the yield is greatest for each compound is not the same for all of them. The temper-



**Figure 4.** Yield experimental data of phenol, guaiacol, and syringol derivatives of the flavoring preparations versus maximum temperature reached in each run; curve lines corresponding to eq 1 and coefficients in Table 2.



**Figure 5.** Yield experimental data of some groups of carbonyl derivatives of the flavoring preparations versus maximum temperature reached in each run; curve lines corresponding to eqs 1 or 2 and coefficients in Table 2.

ature predicted for the optimum yield of total flavor compounds in this study is 503 °C. Probably, the nature of the wood used and the other parameters that govern smoke generation decisively influence the smoldering temperature at which the yield of the flavor compounds is maximized.

The temperatures at which the optimum yields of phenol derivatives are obtained are in general higher than the temperatures at which the greatest yields of carbonyl derivatives are obtained. Among phenol derivatives, the highest yield of guaiacol is found at a temperature lower than those that cause the highest yield of the others. Among the carbonyl derivatives tested, the highest yield of maltol, 2(5*H*)-furanone, and cyclotene is obtained at run temperatures higher than those that produce the highest yield of the others.

From this study it can be concluded that the concentrations of the components of the aqueous smoke preparations here obtained from *V. vinifera* L. shoot sawdust are apparently not influenced by the rate and

length of heating in the smoke generation, but are highly affected by the maximum temperature reached in the process. There is a general behavior that the optimum yield of each compound is obtained at a specific maximum process temperature. When the process is carried out at higher or lower temperatures than those specified, the yield of the compound in question diminishes. The fitting of the yield and of the maximum temperature data by polynomial regressions gives equations that are useful for predicting the maximum temperature of the process at which the yield of a compound or of a group of compounds is greatest. From these results it can be finally concluded that, starting from a specific wood, it is possible to obtain smoke flavoring preparations with expected organoleptic properties by selecting the maximum temperature at which the smoke generation is carried out. When the smoke generation of the *V. vinifera* L. shoot sawdust is carried out at a maximum temperature under (above) that which produces the optimum overall yield in all flavor compounds, the smoke and the aqueous smoke flavoring preparations obtained are richer (poorer) in carbonyl derivatives, which have basically sweet, burnt, caramel flavor (Kim et al., 1974; Baltes et al., 1981; Toth and Potthast, 1984), and poorer (richer) in phenol derivatives, which contribute basically with pungent, cresolic, and smoky flavor (Kim et al., 1974; Baltes et al., 1981; Toth and Potthast, 1984), than when the smoke generation is carried out at the temperature corresponding to the optimum overall yield in all flavor compounds.

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