PERFUMER & FLAVORIST

Spray Drying of Food Flavors—IV. The Influence of Flavor Solvent on Retention of Volatile Flavors

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Flavors are occasionally spray dried without a flavor solvent but more frequently are first compounded with solvent and emulsified into a starch (or gum): water system for spray drying. Some of the more common flavor solvents include ethanol, propylene glycol, benzyl alcohol, triacetin, triethyl citrate and vegetable oil. While a single solvent may be used, it is common to use a mixed solvent containing two or three solvents. Ethanol and propylene glycol are used for water soluble flavoring while the other solvents yield emulsions or fat soluble flavorings.

This is the fourth paper in our series studying flavor retention during spray drying of artificial flavors.[1-3] In this paper, we address the problem of selecting a suitable flavor solvent system for spray drying.

The following research is directed toward determining the influence of flavor solvent on the retention of volatile flavor compounds during spray drying.

Materials and Methods

A model flavor mixture was prepared by mixing equal weights of diacetyl, ethyl acetate, ethyl propionate, ethyl butyrate, butyl acetate, 2-heptanone, ethyl valerate, benzaldehyde, ethyl hexanoate, limonene, actophenone, phenylethyl alcohol, benzyl acetate, methyl salicylate, carvone, methyl anthranilate, ethylmethylphenyl glycidate, isoeugenol and β-ionone together just prior to spray drying. This flavor mixture was then added to the desired solvent (9 parts solvent:1

0272-2666/88/0004-0101$04.00/00—

Perfumer & Flavorist (ISSN 0272-2666)
An Allured Publication
Volume 13, Number 4
August/September 1988

Table I. The Influence of Flavor Solvent on the Retention of Flavor Compounds During Spray Drying

Flavor Compounds	Flavor Solvent			
	Alcohol	Propylene Glycol	Triethyl Citrate	Vegetable Oil
	% Retention[1]			
Diacetyl	23	39	65	59
Ethyl acetate	19	25	41	29
Ethyl propionate	30	26	61	50
Ethyl butyrate	52	52	77	70
Butyl acetate	52	50	76	81
2-Heptanone	61	66	81	81
Ethyl valerate	70	72	91	84
Benzaldehyde	82	63	78	70
Ethyl hexanoate	84	91	98	90
Limonene	84	90	92	86
Acetophenone	80	91	97	96
Phenylethyl alcohol	80	86	100	90
Benzyl acetate	83	88	100	96
Methyl salicylate	83	84	97	95
Carvone	84	88	99	99
Methyl anthranilate	86	97	103	100
Ethylmethylphenyl glycidate	100	103	102	98
Isoeugenol	92	97	100	101
β-Ionone	100	103	99	91
Average[2]	71	74	87	82

[1]Percent of compound remaining following spray drying
[2]Average of three drying runs

part flavor).

A gum arabic solution was prepared 24 hours in advance of drying by mixing warm water (1400 g at 130°F) with gum arabic (600 g) using a Greerco Corp. high shear mixer. The emulsion for spray drying had the following final composition: Gum arabic 28%, water 65%, flavor solvent (if used) 6.2% and active flavor compounds 0.8%. This emulsion would theoretically yield a powder of 80% carrier and 20% flavor system.

Immediately prior to spray drying, the gum solution was blended for 1 minute at a high shear rate. The flavor system was added and then blending continued for an additional 2 minutes. The sample was then spray dried. Sample order for spray dryings was randomized and the experiment was repeated on three different days.

A Niro utility spray drier, fitted with a centrifugal atomizer, was used in this study. An inlet air temperature of 200°C and exit air temperature of 100°C were used. Under these conditions, approximately 15 kg of water was evaporated per hour.

Flavor retention was determined via the acetone precipitation technique as described by Kernik et al.[4] The quantity of each flavor component was determined in the infeed matrix and also after reconstitution of the spray dried flavoring. The ratio of concentrations yielded percent retention.

Results and Discussion

An effort was made to study the retention of water and fat soluble flavor compounds during spray drying using either water or fat soluble flavor solvents. One would expect the fat soluble flavor compounds to be retained better when a fat soluble solvent was used. This is because the flavor compounds would be dissolved in the solvent droplets (emulsion) and exhibit both a reduced vapor pressure (relative to being dispersed

in water) and greater resistance to diffusion.[5] This would result in less evaporative losses during drying. One would not expect a water soluble solvent to have a significant effect upon the retention of either water or fat soluble flavor compounds.

As can be seen in Table I, there was an obvious improvement in the retention of flavor compounds when a fat soluble flavor solvent was used in flavor formulation. This is in agreement with what one would expect on a theoretical basis.[5] One should recognize, however, that the flavor systems employing water-soluble flavor solvents also formed emulsions. In these cases (i.e., the use of alcohol and propylene glycol solvents), the flavorants themselves formed the fat-soluble particulate phases because the flavorants are present in the infeed material well above their solubility limits. However, the flavor compounds present in these flavor emulsion particles most likely exhibited a higher vapor pressure than the same flavor chemicals in the fat-soluble solvent systems. This is expected because the flavor compounds in the water-soluble system were more concentrated (i.e., they were not diluted with the flavor solvent). If the flavor compounds would not have formed an emulsion, one would have expected to see even greater losses in the water-soluble flavor solvent systems.

The improvement in overall retention of flavor compounds when using propylene glycol vs. ethanol as a flavor solvent could also be anticipated. While neither of these two solvents afford any vapor pressure lowering or reduced diffusivity to the volatile flavor compounds, the ethanol could have a detrimental effect on flavor retention by promoting "ballooning" of the drying droplet in the spray dryer. Ballooning occurs when a portion of the water (or water/ethanol when ethanol is used as the flavor solvent) changes to vapor inside the drying droplet. This vapor formation results in expansion of the drying droplet thereby producing particles with greater surface area and thinner walls. Greater surface area and thinner particle walls enhance the loss of volatiles from the drying droplets and, therefore, reduce overall flavor retention.

Conclusions

The conclusion one may derive from this study is to avoid alcohol as a flavor solvent if at all possible. Perhaps propylene glycol can be substituted. A second conclusion is to use vegetable oil, triacetin and/or triethyl citrate as flavor solvents. They benefit the retention of volatile flavors during spray drying.

While we are aware that considerations other than flavor retention may dictate the choice of flavor solvent, we hope that this study will help in selection of a flavor solvent for flavors designed specifically for spray drying.

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