Spray Drying of Food Flavors. III. Optimum Infeed Concentrations for the Retention of Artificial Flavors

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Nearly all of the theoretical work and much of the practical work studying flavor retention suggests that flavor retention increases as infeed solids content increases.[1-5] The accepted theories on flavor retention note that flavors are lost during drying only until the drying droplet forms a semipermeable skin. It follows that the higher the initial solids content, the shorter the time until this semipermeable membrane is formed and the less volatile flavors are lost. This theory would appear to become invalid, however, during the encapsulation of artificial flavors (i.e., flavor chemicals constitute a significant fraction of the drying matrix) using very high infeed solids levels. One would expect to exceed the solubility limits of the encapsulating polymer (e.g., gum arabic) and therefore actually experience greater flavor losses during drying. Since one typically maintains a fixed ratio between carrier solids and flavor material (e.g., 80:20), if the carrier becomes insoluble, there actually is less polymer per unit flavor for encapsulation. Therefore, we address this relationship between infeed dryer solids and flavor retention during spray drying.

Materials and Methods

Three flavor encapsulating agents were used in this study: gum arabic, N-Lok (National Starch Corp.) and Maltrin M-100 (Grain Processing Corp.). The Maltrin and N-Lok were reconstituted (400g solids plus the appropriate amount of water) with heating to 40, 45, 50, 55 and 60% solids one day prior to drying. Due to viscosity limitations, gum arabic was reconstituted only to 30, 35, 40, 45 and 50% solids.

The day of spray drying, the flavor compounds were mixed in bulk and then individual batches weighed out for drying (100g). The flavor mixture was an equal weight of diacetyl, ethyl acetate, ethyl propionate, ethyl isobutyrate, ethyl butyrate, butyl acetate, ethyl valerate, ethyl hexanoate, 2-heptanone, benzaldehyde, acetophenone, phenyl ethyl alcohol, benzyl acetate, methyl salicylate, L-carvone, methyl anthranilate, vanillin, isoeugenol, β-ionone and ethyl methyl phenyl glycidate.

Immediately prior to spray drying each sample, the aqueous solution was blended for one minute at a high shear rate using a Greerco Laboratory model mixer. The flavor mixture was added and blending continued for an additional two minutes. Since some of the emulsions were not stable, the gum/flavor emulsions were stirred gently while being fed into the spray dryer.

A Niro Utility Model spray dryer was used in this study with an inlet air temperature of 200°C and an exit air temperature of 100°C.

Retention of volatiles was determined by the gas chromatographic method as previously re-

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ported. The quantity of each volatile was determined in the infeed matrix and then after reconstitution of the spray dried mateial, the ratio of concentrations yielded percent retention.

Results

The average retention of all twenty volatile flavor components as a function of infeed solids content is presented in Table I. The solids level listed is of the gum/water solution prior to the addition of flavor. It appears from this table that each flavor encapsulation material does have an optimum infeed solids level as determined by flavor retention. Gum arabic exhibited the best overall retention when the infeed solid was 40%, while N-Lok and Maltrin M-100 showed optimum retention at infeed solids of 45%.

The true influence of infeed solids on flavor retention is not shown very effectively by the average retentions presented in Table I. This is because the most volatile components are influenced by infeed solids to the greatest extent and the average retentions do not reflect these individual values very well. It is of greater value to look at the retention of individual flavor compounds as a function of infeed solids. For this purpose, the retention of individual flavor components at different infeed concentrations of N-Lok are shown in Table II.* An examination of this table suggests that an infeed gum/water concentration of 50% total solids may be the best for spray drying. While a little has been lost on retention of the high boilers, substantial improvements have been gained in retention of the low boilers.

Table I. The Influence of Infeed Solids Content on the Average Retention of a Model Flavor System During Spray Drying

% Total Solids	% Flavor Retention (a) Gum Arabic	N-Lok	Maltrin M-100
30	71	-(b)	-
35	76	-	-
40	80	75	58
45	76	78	64
50	74	77	51
55	-	75	38
60	-	71	37

(a) Average of all compounds and duplicate runs
(b) Not determined

Table II. The Influence of Infeed Solids Content (N-Lok) on the Retention of Individual Flavor Components During Spray Drying

Compound*	Infeed Solids (%) 40	45	50	55	60
	Percent Retention				
Diacetyl	63	65	66	63	64
Ethyl acetate	42	55	61	58	45
Ethyl propionate	62	70	73	67	57
Ethyl isobutyrate	73	78	79	72	61
Butyl acetate	77	81	82	76	66
2-Heptanone	74	78	79	73	63
Ethyl valerate	74	77	78	73	68
Benzaldehyde	79	83	82	76	66
Ethyl hexanoate	71	76	76	74	70
Acetophenone	83	85	85	79	70
Phenyl ethyl alcohol	76	77	79	77	75
Benzyl acetate	75	78	74	78	83
Methyl salicylate	87	83	82	79	75
Carvone	81	82	81	79	76
Methyl anthranilate	81	82	81	79	75
Vanillin	80	82	76	78	78
Isoeugenol	79	80	72	77	81
Ionone	80	82	80	79	80
Ethyl methyl phenyl glycidate	84	87	84	83	87
Overall average:	75	78	77	75	71

* Listed in order of elution from the GC

* Data on gum arabic and Maltrin M-100 were so similar to that of N-Lok in overall trend that they are not included here.

Conclusion

This work demonstrates that each flavor encapsulating agent has an optimum infeed concentration if maximum flavor retention is desired. The reason for this optimum is not entirely certain. We have proposed the theory that at sufficiently high infeed solids, the gum is no longer soluble and therefore cannot afford protection against evaporation of the volatile flavor components during the drying operation.

An alternative hypothesis might also be in effect. That is that at very high solids levels, we can not effectively atomize the infeed material and particle shape is no longer spherical.

Maximum flavor retention is achieved when spherical droplets are obtained since a sphere has the minimum surface to mass ratio. We observed nearly cylindrical, stringy powder particles when the very high solids levels were used in this study. Thus, while we observe an optimum in flavor retention as influenced by infeed solids, we cannot fully explain the reason for its existence.

The practical aspects of this work are that each flavor encapsulating material will exhibit an optimum concentration for flavor retention. The optimum concentrations determined in our study may not necessarily be the same as in a production facility. This would have to be determined using actual production equipment. If the retention is limited by the ability to atomize, this factor is equipment dependent. It does appear worthwhile to make this determination, however.

The higher one can go in infeed solids, the more flavor is being produced per hour. Remember that we always maintained a ratio of 4 parts carrier to one part flavor. As solids content went up, so did flavor through put. Perhaps a decision would even be made that the small decrease in retention observed with some carriers above the optimum infeed solids is tolerable in order to increase manufacturing output.

References

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