Fats in microencapsulation applications : benefits and challenges

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INTRODUCTION

Naturally-occurring and modified fats have been used extensively in various microencapsulation and controlled release systems mainly for taste-masking of objectionable actives, protection of water-sensitive components and most frequently for heat-triggered release applications. The main criteria in choosing an ingredient for encapsulation applications is the ingredient's ability to form a stable film which can withstand food processing and storage conditions without adverse effects on the product's sensory attributes. Due to their unique physicochemical properties and compatible/bland taste profile, plant-derived fats have been adapted to a wide range of microencapsulation and controlled release technologies such as spray drying, spray chilling, particle coating as well as others (King et al., 1996; Hui, 2004; Onwulata et al., 1996).

Plant-derived fats are essentially neutral triacylglycerols (TAGs) made-up of 3 similar or dissimilar fatty acids attached to the glycerol backbone. The type of fatty acid chains, their length, degree of saturation as well as their position on the glycerol stem can have a significant impact on the fat's melting behavior, its rheology and crystallinity and subsequently its film-forming properties (Hartel, 2001; Marangoni et al., 2006; Timms, 1984).

One of the most challenging controlled release applications in food systems is designing microcapsules for entrapping moisture-sensitive actives with a desired heat-triggered release mechanism. In such formulations, the delivery system should be tightly impermeable to water upon storage but can readily release the active in a narrow window of time and temperature. These two constraints can ideally be accomplished by encapsulating the moisture-sensitive active in a hydrophobic meltable carrier such as fats and waxes. Unfortunately, most commercially-available food grade fats and waxes are supplied as blends whose physicochemical properties such as melting profile, viscosity and other rheological properties are not fully understood; such fats have most often been found to be unsuitable in most microencapsulation applications if used as such.

The main objectives of this study were :

- Comparing the encapsulation attributes of a group of fats and waxes that differ in their composition, melting points and rheological properties. The three fats selected for this study were: i) TAG-46 and TAG-62 (triacylglycerols with melting points 46 and 62^{o}C, respectively), ii) carnauba wax (melting point 86^{o}C) and iii) their combinations.

- Correlating the active's release profile to the inherent physicochemical properties of the encapsulating fat material and encapsulation technology.

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MATERIALS AND METHODS

Fluid bed coating :

Coating equipment	Glatt GPC-G5	Glatt GPC-G5	Glatt GPC-G5
Operational mode	Top Spray	Top Spray	Top Spray
Substrate	Sodium bicarbonate	Sodium bicarbonate	Sodium bicarbonate
Coating material	TAG46	TAG62	TAG62 + carnauba wax
Spray rate (g/min)	17	19	23
Batch weight (kg)	5	5	5
T_{inlet} (^{o}C)	26	35	55
$T_{product}$ (^{o}C)	24	38	53

Differential Scanning Calorimetry (DSC) :

Melting profiles of the two TAGs and their combinations with carnauba wax were examined using DSC (TA Instruments, Mississauga, ON). 10 mg samples of fat were melted and placed in hermetically-sealed DSC pans and heated from 20 ^{o}C to 100 ^{o}C at a heating rate of 5 ^{o}C /min. An empty pan was used as a reference.

Characterization of Encapsulated Soda :

Actual payload of sodium bicarbonate was determined by carefully dispersing the coated material in water, titrating with hydrochloric acid to determine the amount of bicarbonate available for acid neutralization.

Morphology of coated particles was studied using light and scanning electron microscopy. Light microscopy (Carl Zeiss, Germany) was used to characterize surface properties of coated particles using Nile Red staining while the microcapsules' internal structure was viewed using scanning electron microscopy (Hitachi S-6000, Japan).

Release Profile :

Simulated and actual release profiles of encapsulated sodium bicarbonate were determined in water and in baked formula, respectively. Results were expressed as amounts of CO_2 evolved as a function of time.

RESULTS AND DISCUSSION

Microcapsules destined for food formulations must, generally, be able to withstand a host of challenging conditions such as mixing, shear and processing temperature, moisture or other stressful environments. In the case of fat-based microparticles, the fat should have relatively high melting point to survive potential fluctuations in storage temperatures yet should possess adequate plasticity necessary for film formation upon particle coating or spraying. Other considerations include adequate microcapsule particle size, porosity, tackiness, etc.

Encapsulation process efficiency

Ease and efficiency of the encapsulation process showed gradual improvement as the fat melting point increased; despite the need for better temperature control, wax-containing formulas processed much easier than those made with the low melting TAGs. At higher coat:core ratios, efficiency dropped significantly for the low melting fat where the fat material appeared to smear around the particles until no further processing was possible. TAG-46 was the worst performing fat under these microencapsulation conditions.

Microcapsule morphology and integrity

Morphology of microcapsules made with TAG-46 and TAG-62 appeared to be fairly smooth and uniform whereas those made with carnauba showed some surface roughness. Incorporating emulsifiers into fat and wax compositions resulted in improved coating efficiency and better microcapsule integrity. Upon heating, TAGs encapsulated microparticles showed quick release of the active while release from their wax-containing counterparts appeared to display a more controlled behavior **(Figure 1.b & 1.d**).

Performance in baked food system:

Of all three microencapsulation systems tested, the combined wax/TAG system showed superior performance resulting in a baked product with good cell structure and high baking quality, an indication of adequate rate of release throughout the product's baking cycle. The baking temperature simulations along with actual baking results may allow for a realistic prediction of the release mechanism.

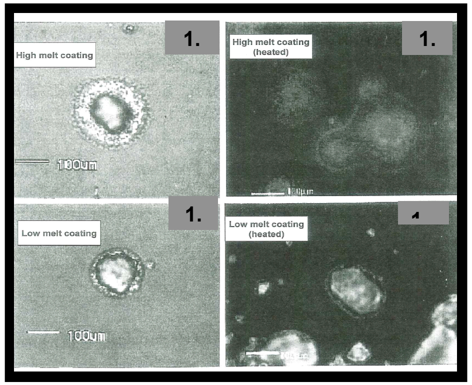

Figure 1. Light micrographs for microcapsules prepared using (a) TAG-62/carnauba wax unheated, (b) TAG-62/carnauba wax heated, (c) TAG-62 unheated and (d) TAG-62 heated. A heated stage microscope was used for this experiment.

CONCLUSIONS

Fats with different melting points and degrees of plasticity were used for encapsulating moisture sensitive actives for their heat-triggered release in a bakery food system. Plastic fats and their combination with high melting carnauba wax provided good processability and controlled release both in a simulated and actual baked food systems. A mechanism for releasing water soluble actives from fat and wax matrices is therefore suggested.

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