Back to the future to improve performance

by Chris Kamel, Carotenoid Technologies, IQF Group, Tarragona, Spain.

A European consortium including centres in Spain, France, Germany and the UK are starting to bring to light know how on improving stability, dispersibility and effectiveness of micro-additives based on plant extracts.

European regulations require that these new additives be extensively assessed for efficacy, toxicity and safety, or remain as plant extracts, under their flavour classification. This will directly affect how they are commercialised to the industry in the future.

We are now at the mid-point between the establishment of the new EU Directive 1831/2003 and the registration deadline, and indeed the focus has to be toward the future regulatory approval. So, what have we learned about these products and how will this help companies decide on which commercial products to base their future, sustainable company strategies?

This article will focus on the solutions for plant extract products based on the active scientific research and development from the public and private sector.

Stability from the inside

Understanding stability and how it affects the efficacy of plant extracts included in animal diets to enhance performance has taxed specialists over the years.

This has been hampered by the fact that essential oils, produced by steam distillation are complex mixtures, which render difficult the task of relating stability and effectiveness to one or more of its component parts.

Current research suggests that two components may be better than one when considering stability and effectiveness. For example, Jukic and Milos showed that both of these ingredients when presented alone had the capacity to undergo oxidative transformation to a different molecule, a thymoquinone or related compound.

Trials have shown that the stability of the 1:1 pairing was significantly higher than thymol alone – it being slightly more stable than carvacrol. This reaction was in turn catalysed by the presence of certain minerals commonly present in vitamin mineral premix formulations.

Protective encapsulation systems have also been found to provide additional benefits to phytogenic compound stability. Micro-encapsulation can be carried out by various methods, including spray drying, spray cooling and fluid bed techniques.

Studies up to now have shown that the success of protection of non-nutritive additives, such as plant extracts and their active ingredients, depends largely on relating the type of encapsulation protection with the active material to be coated, the animal production objectives and the species of animal targeted. The main interest behind micro-encapsulation protection of additives is their potential to:

- Improve handling characteristics and reduce dustiness.
- Improve off-taste masking.
- Reduce caking and hydroscopicity.
- Extend pelleting, expanding and storage stability.
- Enable controlled release for improved targeting of active ingredients.

Even though the concepts of micro-encapsulation and controlled release are relatively old, attention to these concepts with respect to plant extracts has only been recent. Enhance, a patent pending process developed in Tarragona, Spain, benefits the physical stability and delivery of the active ingredients it encapsulates.

This method includes a two step encapsulation process which is unique in two ways. First, it enables active material to be concentrated by up to 57% in a single particle. Second, it allows for the full encapsulation of particles by a special layer of mono and diglycerides ensuring all active components are retained below the surface (see photograph).

They can improve the physical characteristics of a dry product, especially with respect to handling and behaviour in modern feed production and they provide a differential

Continued on page 12

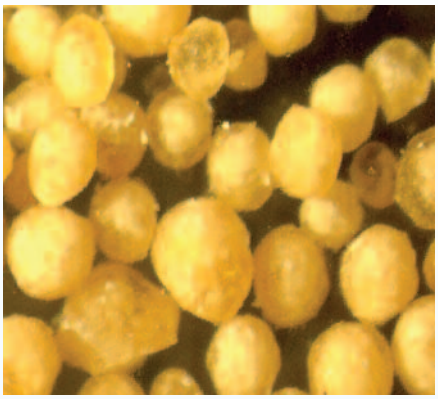
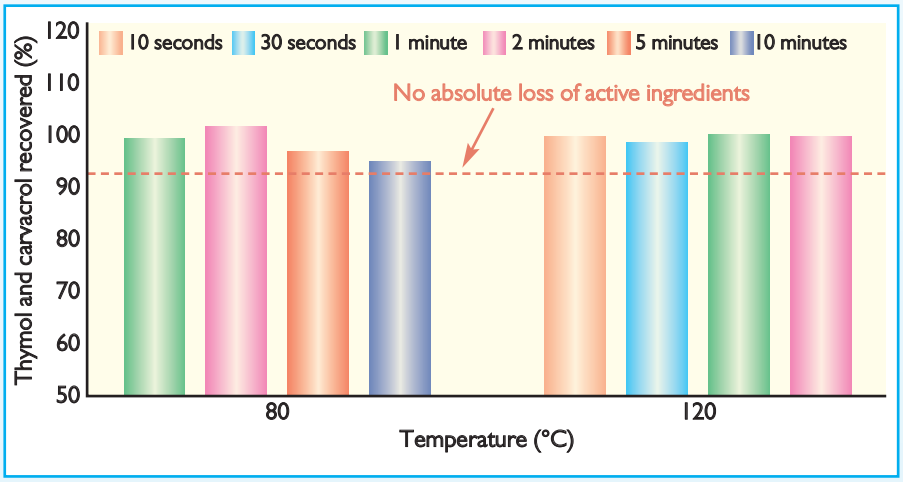


Photo at 40X magnification of the 1:1 combination thymol and carvacrol enhanced by a patent pending encapsulation process to protect against loss of active ingredients, palatability problems and potential release to the lower gut.

Fig. 1. Stability of Enhance (protected 1:1 combination of thymol and carvacrol) under pelleting and expanding conditions as determined by gas chromatography.



Continued from page 11
release of active substances in the animal.

The combination of a stable formulation such as 1:1 thymol and carvacrol along with an effective protective encapsulation, such as Enhance leads to benefits under stress conditions. Stress conditions here can be both physical and pathogenic in nature.

Plant extracts represent one of the classes of feed additives most affected by processing conditions. The stability of active ingredients during processing is very important, especially for high temperature treatments.

Pelleting and expanding are two such processes that have gained immense popularity in feed processing. During these processes plant based active ingredients go through mixing, heating and shearing at high temperatures, with shear and pressure resulting in losses by transformation of the molecules. A number of flavour components have been shown to flash off or convert with steam during expansion due to the sudden pressure drop at the die.

One of several studies is shown in Fig. 1, where the encapsulated 1:1 combination of thymol and carvacrol remained stable over pelleting and expanding conditions.

Physical aspects of micro-additives not only benchmark their dispersibility in feed formulations, but their safety for handlers in today's premixing and finished feed plants.

There is no place for products which tend to be dusty, electrostatic, or hydroscopic. There are specific industry accepted indices for characteristics of feed micro-additives, such as, the particle size, the angle of repose and the index of compressibility.

The exact angle at which loose, non-cohesive material remains stable, called the angle of repose, depends on several physical characteristics of the material making up the slope. The physical characteristics include size, shape, roughness of the particles, density of the debris and sorting or mixture of sizes.

Nutritionists and engineers should be interested in the angle of repose of microadditives for a variety of reasons. For example, if a material has a high angle of repose, it is prone to bridging with itself and other feed ingredients, leading to reduced dispersibility and homogeneity in the feed.

In studies using a Zeta Plus dynamic light scattering particle size analyzer (Brookhaven Instrument Corp, Holtsville, New York), the Enhance protection system showed an improved mean particle size and a lower spread of size as indicated by a lower standard deviation from the particle population.

This reduces the problem of segregation of micro-ingredients and assures that the particles disperse optimally in the feed matrix.

The index of compressibility is another indication of product stability as it measures the percent of particles to become friable under a given force, in this case a comparison of unprotected and Enhance protection particles show a significant difference under pressures common to feed pelleting.

While over 40% of uncoated material becomes friable under the compression conditions, this value is reduced with the Enhance technology, indicating that more whole particles make it through the die at pelleting.

Targeting strategies for active ingredients is limited in the feed industry by the types of ingredients available, and even more by the limited coating materials available and permitted under European feed legislation. In general, categories of materials permitted by the legislation include fats, celluloses, and starches.

Synthetic polymers, which have been studied extensively for their release properties and are common in food and pharmaceutical applications, are not permitted. In the feed additive area, the most studied system is that involving microcapsules made by spray cooling a water-in-oil type emulsion.

The microcapsules, in aggregate, are a dry, free flowing powder and can be heated or otherwise processed to release their contents. However, this technique is limited by production costs which limit the amount of coating that can be loaded and because the materials encapsulated readily dissolve and/or disperses into the shell.

The most common application is the addition of hydrogenated fats to encapsulate materials such as methionine or choline for rumen bypass applications. This is due to the high melting point of the hydrogenated

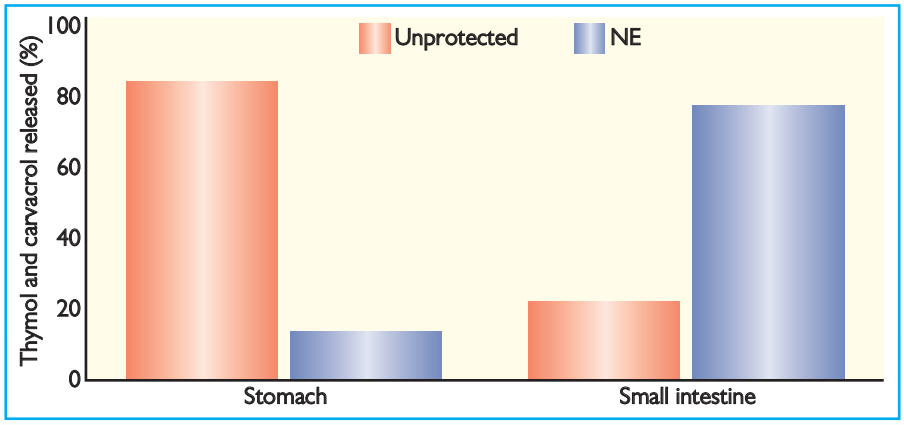


Fig. 2. Results from a series of three studies using a modified flow through cell system simulating the stomach and small intestine of the young monogastric animal. Results show the quantitative release in the stomach and small intestine compartments over two to eight hours, respectively, of 1:1 thymol and carvacrol in an unprotected form compared to a protected 1:1 combination of thymol and carvacrol (NE).

fat material (which is often higher than the 40°C found in the rumen). However, this application cannot be routinely used in the single stomached animal, as different principles such as enzyme activities, pH and osmolality apply and must be taken into account accordingly to improve efficacy.

Therefore, the choice of the individual phytomolecules and an appropriate protective matrix can lead potentially to their administration in a sustainable, controlled fashion. The Enhance concept of the full encapsulation of active ingredients absorbed onto a hardened core and coated by a special layer of mono and di-glycerides subunits upon which lingual and gastric lipases would have little effect, is a logical approach.

Preliminary trials have confirmed that this approach, using dissolution cell models simulating the gastric and small intestine characteristics of the young animal, showed differences of the Enhance system to alter the release kinetics of a 1:1 stable combination of thymol and carvacrol versus the unprotected combination.

As shown in Fig. 2, the Enhance system significantly released more of the active ingredients in the small intestine compared to the unprotected sample.

Animal studies in a number of external trial sites have also shown the benefits of an encapsulated form of a 1:1 combination of thymol and carvacrol. One project conducted under the auspices of the University of Leeds tested the product in a series of 16 sequential trials with broilers from 1-42 days of age.

The results of this series (Fig. 3) showed benefits in broiler flocks of the protective encapsulation of 1:1 combination of thymol and carvacrol in over 70% of the trials by improving either liveweight gain and/or feed conversion ratio by 3-4%.

Future solutions

European legislation in 2003 set the guidelines for the future of these additives which, will impose important financial and technical barriers to the current suppliers of plant extracts.

Finally, this will certainly give suppliers with unique raw material and powder technologies a clear advantage over their competitors in bringing a new, sustainable additive to the market. But this will certainly be advantageous in the long run as it will finally seek out sustainable, cost effective solutions for the poultry industry. ■

Fig. 3. Summary of 16 consecutive field trials of the feeding of encapsulated 1:1 thymol and carvacrol (NE) in broiler diets on liveweight gain and feed conversion ratio from 1-42 days of age.