MICROENCAPSULATED (Powdered) TOCOTRIENOL-RICH-FRACTION (TRF)

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Microencapsulation is defined as the incorporation or entrapment of food ingredients, enzymes, cells, vitamins, flavours, antioxidants or other materials in small capsules. Microcapsules are used as means to protect sensitive food components or ingredients, avoid nutritional loss, incorporate unusual ingredients, enhance time-release mechanisms of the ingredients, mask or preserve flavours and aromas, and transform liquids into easily handled solid ingredients. Microcapsules can range in size from 50 nm to a few hundred micrometers, with micron-sized capsules being the most widely used. Commercial microcapsules typically have a diameter of from 3 to 800 µm (Kamyshny *et al.*, 2006).

Various techniques have been employed to form microcapsules, including spray drying, spray chilling or spray cooling, extrusion coating, fluidised-bed coating, liposome entrapment, coacervation, centrifugal extrusion, rotational suspension separation and supercritical fluid technology. However, commercially, spray-drying has been the most widely used microencapsulation technique in the food industry and is typically used for the preparation of dry, stable food additives and flavours (Okuyama *et al.*, 2006; Picot and Lacroix, 2003). The process is economical and flexible because it offers substantial variation in microencapsulation matrix; is adaptable for common processing equipment; and produces particles of good quality (Desai, 2005; Gharsallaoui *et al.*, 2007; Champagne and Fustier 2007; Gouin, 2004).

Wall materials may consist of fats, starches, dextrins, alginates, protein and lipid materials (Desai, 2005). They should have a good rheological property to provide the core materials with the required structure and protection. Proteins and polysaccharides are the two most important biopolymers used in food emulsions to control their texture, microstructure and stability. Moschakis *et al.*, (2010) found that the emulsion behaviour and microstructure depended on the precise polysaccharide proportion when whey protein isolate, gum arabic and chitosan were used in the emulsions. The polysaccharides aided their aggregation with the protein-coated emulsion droplets. Compatible blends of biopolymers (hydrocolloids and proteins) are claimed as excellent future amphiphilic macromolecules that will serve as both 'release controllers' and 'stability enhancers' under certain combinations, for the future preparations of double emulsions (Benichou *et al.*, 2004, Lutz *et al.*, 2009).

THE INVENTION

Microencapsulated tocotrienol-rich-fraction (TRF) was produced using a spray drying technique (*Figure 1*). Palm olein was used as the TRF carrier because it can encapsulate more TRF, as stipulated in *Figure 2*. The ratio of oil to water (containing wall materials) was 30:70. The wall materials used were carbohydrate (corn syrup solids, CSS) and protein (whey protein isolate, WPI).

Figure 1. Microencapsulated (powdered) tocotrienol-rich-fraction (TRF).

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TABLE 1. PARTICLE SIZE AND DISTRIBUTION PROPERTIES OF MPOB AND COMMERCIAL POWDERED TOCOTRIENOL-RICH-FRACTION (TRF)

Parameters	MPOB spray dried TRF	Commercial spray dried TRF
Particle size vol. weighted mean, μm	23.83	267.91
Particle size uniformity coefficient	1.53	1.61
Particle size span	2.66	5.44
Microencapsulation efficiency, %	41.07	4.17

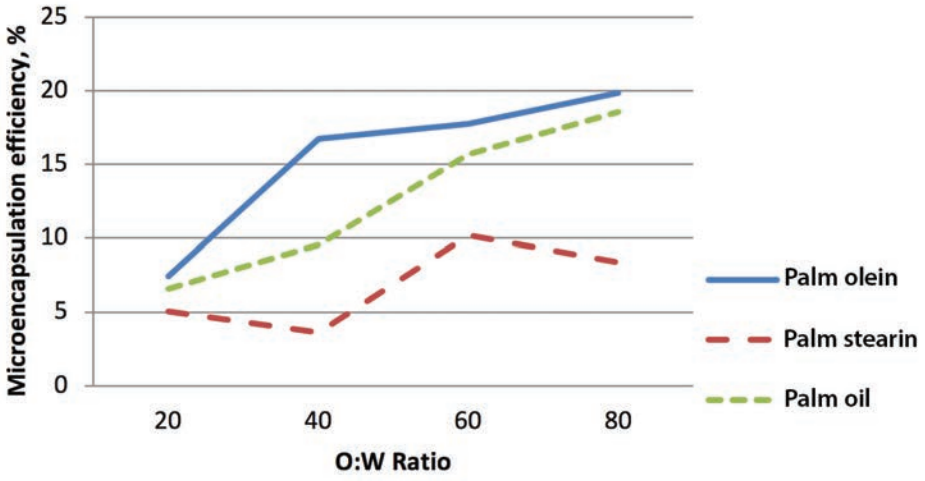

Figure 2. Microencapsulation efficiency of samples at different oil to water ratio.

The volume weighted mean of microcapsules in the cyclone ranged from 15.88 μm to 71.62 μm (mean 23.83 μm). Whereas, as shown in *Table 1*, the microencapsulation efficiency of 3.61% to 41.07% was recorded better than the commercial powdered TRF.

Total solids significantly ($P<0.05$) influenced the particle size and size distribution of the microcapsules. The pressure applied during homogenisation and the amount of WPI significantly ($P<0.05$) affected the microencapsulation efficiency of the microcapsules. Interaction between the two factors also gave a noteworthy effect ($P<0.05$) to the microencapsulation efficiency values.

The free radical scavening activities were determined by the 1,1-diphenyl-2-picrylhydrazyl (DPPH), in which Superoxide Radical Scavenging Assay (SRSA) and Ferric Reducing Antioxidant Power (FRAP) assays were highly correlated.

The microencapsulated TRF performed well in beverages formulations. It has a good antioxidant activity in beverages (analysed by free radical scavenging activity). The addition of microencapsulated TRF into these beverages has no significant effect on the viscosity of the beverages. Microencapsulated TRF could be easily delivered in aqueous matrixes without causing too much interference with the original taste and texture.

NOVELTY OF THE PRODUCT

- Microencapsulated TRF with good microencapsulation efficiency (> 40%).
- Microencapsulated TRF with excellent free radical scavenging activity.
- Vitamin E content of 50-90 mg g^{-1} could be easily encapsulated.

ECONOMIC ANALYSIS

The estimated expenditure and other economic evaluation are shown in *Table 2*. This economic evaluation is based on the assumption that the spray dried TRF is sold at RM 1280 kg^{-1} (ex-factory price) and consistent production capacity of 120 t yr^{-1} (capacity utilisation from 20% to 40%, gradual increment in 10 years). The current prices of commercial spray dried TRF are RM 1500 to RM 1800 kg^{-1}. Target markets are local, including small and medium enterprises, and overseas manufacturers.

TABLE 2. ECONOMIC VALUES OF SPRAY DRIED TOCOTRIENOL-RICH-FRACTION

Economic analysis	Value
Cost (materials), RM kg^{-1}	1 038
Selling price, RM kg^{-1}	1 280
Capital expenditure (including purchase of building, spray dryer and agglomerator), RM	8 450 000
Net present value (NPV) at 10%, RM	24 267 603
Internal rate of return (IRR), %	49.57
Discounted payback period	2 yr 9 mth
Discounted benefit to cost ratio	1.10

CONCLUSION

Microencapsulated TRF with WPI and CSS as the coating materials has a great commercial value for its cost effectiveness and its free radical scavenging is traceable to the finished products.

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