Abstract

The aims of the present study were to apply the nanotechnology knowledge on the horsetail extract which was an important ingredient in hair and scalp care products as well as research and develop the prototype nano cosmeceutical products for hair and scalp which were safe and commercial use.

In this study, 12 potential plants were selected, including horsetail (*Equisetum debile*), sweet flag (*Acorus calamus*), ginger (*Zingiber officinale*), Plai (*Zingiber cassumunar*), galanga (*Alpinia galangal*), turmeric (*Curcuma longa*), rosemary (*Rosmarinus officinalis*), oregano (*Origanum vulgare*), lavender (*Lavandula angustifolia*), tung (*Aleurites moluccanus*), rice bran (*Oryza sativa*), and perilla (*Perilla frutescens*) and 3 types of plant extracts were prepared, including crude extract, essential oil, and vegetable oil or fat. The cytotoxicity of local highland plant extracts investigated in dermal papilla cell line noted that both ethanolic and de-chlorophyll horsetail extracts at the concentration of 1 mg/ml were safe with the call availability of 103.14±2.87% and 100.36±0.92, respectively. These results indicated that both extracts could stimulate the growth of dermal papilla cells by 3.14±2.9% and 0.36±0.9%, respectively. Therefore, ethanolic horsetail extract was selected for the further product development in a combination with two more extracts, including sweet flag extract and ginger extract.

In the part of nano formulations development, three types of nano delivery systems were developed, including nanostructure lipid carrier, liposome, and microemulsion. However, nanostructure lipid carrier and microemulsion were more suitable than liposome since liposome had low entrapment capacity and contained high amount of water. The best nanostructure lipid carrier, which has the smallest internal droplet size and the best stability, was composed of 3% glyceryl monostearate-2, 2% Rice bran oil, 93% deionized water, and 2% Span 20. The internal droplet size, polydispersity index, and zeta potential of the nanostructure lipid carrier formulation were 352.73±39.53 nm, 0.60±0.05, and -0.02±0.06 mV, respectively. In the development of nanostructure lipid carrier, the nano formulations containing 0.1% of the plant extracts showed good stability. Additionally, among various nano formulations containing several extracts, only formulation number 7, which composed of horsetail, sweet flag, and ginger extract at the concentration of 0.05%, was stable with the internal droplet size of 457.43 ± 119.52 nm and polydispersity of 0.50 ± 0.09. Moreover, the

hair stimulating products were also developed from nanostructure lipid carrier containing horsetail, sweet flag, and ginger extract. The results noted that formulation A3 had the smallest internal droplet size of 260.4±36.2 nm and the narrowest polydispersity of 0.33±0.01 nm.

The microemulsion which had the smallest internal droplet size and good stability, contained 10.3% rice bran oil, 20.5% Tween 85, 6.8% butylene glycol, 13.7% ethanol, and 48.7 DI water. The internal droplet size, polydispersity index, and zeta potential of the liposome formulation were 71.9±0.7 nm, 0. 99±0. 02, and - 0.38±0. 17 mV, respectively. Additionally, the microemulsion containing local highland plant extracts (formulation B) was developed with the concentrations of the horsetail, sweet flag, and ginger extract of 0.1%. Menthol, rosemary oil, ginger oil, and peppermint oil were used for the flavor. The of microemulsion containing local highland plant extracts was very stable and its internal droplet size, polydispersity index, and zeta potential were 81.5±0.2 nm, 0. 99±0. 00, and -0.03±0.22 mV, respectively.

Additionally, the volunteers satisfied most by formulation B (4.2±0.6), which gained the highest satisfaction score in all aspects, including appearance and texture (4.3±0.6), color (4.0±0.8), odor (4.2±0.9), greasy and stickiness (4.0±0.7), and the proper use on hair and scalp (4.1±0.8). Therefore, nano formulation B would be the most suitable formulation selected for further efficacy test in the volunteers. The results noted that formulation B had a comparative efficacy in hair fall reduction to the commercial products. The product could reduce hair fall by 46.6±30.8% and 41.6±32.4%, respectively after 7 days. Moreover, they could reduce hair fall by 49.8±28.7% and 46.6±34.2%, respectively after 7 days. Therefore, the nano hair stimulating products containing local highland plant extracts showed a comparable anti-hair fall efficacy to the commercial products. The production cost of this nano hair stimulating products containing local highland plant extracts was 565.24 baht/kg.