accelerated temperature of 50 ºC for seven days at 24 hr interval and it was tested by thiobarbituric acid value. Tristimulus colour values of L*, a* and b* are used as indices of the colour changes in fish oil encapsulates during storage. A decreasing trend in L* (88.95 to 82.03 for CHGM sample; 79.65 to 76.6 for CHGME) was observed under accelerated storage (Fig. 3). Oxidative stability studies revealed that encapsulates prepared with oregano essential oil had lower TBA (0.78 mg malonaldehyde/kg) value than control (8.2 mg malonaldehyde/kg). Results from the study suggested that combined effect of chitosan and oregano essential oil could improve the oxidative stability of fish oil microencapsulates.

Fig. 3. Changes in L* value of microencapsulated fish oil during storage

Importance of marine lipids in human health has been continuously increasing. Many pharmacological studies have shown the medicinal importance of n-3 fatty acids. The unsaturated moieties of omega-3 and omega-6 fatty acids are crucial for their health promoting functions. However, n-3 fatty acids are highly susceptible to oxidation. Oxidation reduces the quality of oil and produces off-flavour through the breakdown of lipid hydro-peroxides. Off flavour and colour degradation of fish oil are the limiting factors for its use in foods. Furthermore, the hydroperoxides generated during lipid oxidation also have been considered to be toxic. Prevention of oxidation of n-3 fatty acids is essential in allowing them to accomplish their original physiological functions. Hence, fish oil needs to be protected from factors that promote oxidation (oxygen, light, free radicals and pro-oxidants). Lipid oxidation of oils can be reduced by the addition of antioxidants or by microencapsulation. Microencapsulation is a very suitable method to facilitate the incorpo-
ration of omega-3 fatty acid into foods. Encapsulation by spray drying is a rapidly expanding technology in pharmaceutical and food industries, wherein a lipophilic active ingredient is loaded within a wall material to form microcapsules. Microencapsulation improves storage stability, ease of handling and controlled delivery of lipophilic active ingredient.

In the present study, microencapsulation of sardine oil by emulsification-spray drying technique was carried out for stabilizing the ω-3 fatty acids. Vanillic acid-grafted chitosan was used as a novel wall material. Further, the oxidative stability was assessed under accelerated oxidative atmosphere by conducting a rancimat test and peroxide value of the encapsulated powder was determined during storage at room temperature.

Stable emulsion of sardine oil and vanillic acid-grafted chitosan was prepared using 0.1% Tween 20 and 8mg of beta-carotene/g of oil. Microscopic structure of emulsion containing 0.1% Tween 20 (Fig. 1) did not show any coalescence. Lower concentration of Tween 20 acted as a protective layer around the droplet in the emulsion and revealed good emulsion stability.

Moisture content of spray dried powder was found to be 2%. Moisture content along with temperature affects the shelf life of dried microcapsules. The maximum moisture specification for most dried powders in the food industry range between 3-4% (Kagami et al., 2003).

Peroxide value of spray dried powder increased slowly during storage period (Fig. 2). The encapsulated oil was found to be less susceptible to lipid peroxidation compared to un-encapsulated one. Peroxide value of fish oil in free form increased throughout storage period. At the end of 4th week, the PV of the un-encapsulated oil reached 27.6 mmol/kg oil. Encapsulated fish oil exhibited slower rates of peroxide formation compared to un-encapsulated oil. The peroxide value of encapsulated fish oil on 4th week reached 5.5 mmol/kg oil only revealing that encapsulated fish oil is more stable than un-encapsulated fish oil.

Moisture content of spray dried powder was found to be 2%. Moisture content along with temperature affects the shelf life of dried microcapsules. The maximum moisture specification for most dried powders in the food industry range between 3-4% (Kagami et al., 2003).

#### Table 1. IP values of microencapsulated oil compared to bulk sardine oil

<table>
<thead>
<tr>
<th>Sample</th>
<th>IPR1 (At 110°)</th>
<th>IP R2 (At 110°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% fish oil</td>
<td>0.67 h:0.01</td>
<td>0.71 h:0.03</td>
</tr>
<tr>
<td>5% encapsulated fish oil</td>
<td>7.67 h±0.05</td>
<td>7.57 h±0.07</td>
</tr>
</tbody>
</table>

The accelerated rancimat test is an easy method (Velasco et al., 2003) to determine the oxidative stability of oils. Encapsulated fish oil was heated under atmospheric pressure at 110 ºC and bubbled with oxygen at constant flow, which can be considered as an accelerated oxidation test. Under these conditions, the lipids get oxidized to short chain volatile acids like formic acid and acetic acid which are collected in distilled water increasing its conductivity. The IP (Induction Point) value indicates the time required to produce a sudden increase of conductivity, which can be defined as an indirect measure of oil stability. Table 1 shows the Induction Point values of microencapsulated oil.
compared to bulk sardine oil. Bulk sardine oil presented an IP of 0.67 ± 0.01 h which is comparable to the value reported for fish oil (0.75 h), whereas microencapsulated oil showed IP value of 7.67 ± 0.05 h. IP values obtained for microcapsules clearly showed a protective effect of the vanillic acid-grafted matrix against sardine oil oxidation.

References


Comparison of the properties of protein hydrolysates from white and red meat of tuna (*Euthynnus affinis*)

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The processing discards from the seafood industry account for nearly three-quarters of the total quantity of fish catch. These discards contain good quantity of valuable nutritional components and the potential utilization of these nutrients for various applications has been the focus of attention in the recent years. Several techniques have been developed to recover the essential nutrients and bioactive compounds from these protein rich fish processing wastes. Enzymatic proteolysis and solubilization of proteins from various sources has been studied extensively and described by several authors for the past few years. By adopting hydrolysis, these proteinaceous fish waste can be converted to hydrolysates with a range of potential applications.

Tuna and related species are very important economically and are rich sources of high quality protein. Converting these wastes to bioactive hydrolysate finds application in a broad spectrum of food ingredients. Protein hydrolysates are mixture of bioactive peptides obtained by the breakdown of proteins by hydrolysis either chemically or enzymatically. Protein-rich red meat from tuna has limited use compared to white meat and is usually processed into low market-value products and hence conversion of this red meat into protein hydrolysates may generate high value products. A comparative study of the properties of hydrolysates derived from tuna white meat and red meat were carried out. Protein hydrolysate was prepared using papain (enzyme: protein; 1:100) for 60 min. under optimal hydrolytic conditions and spray dried to obtain a fine powder of tuna white meat (TWPH) and tuna red meat protein hydrolysates (TRPH).

Determination of protein content of tuna waste and tuna protein hydrolysates (TPH) indicated an increase in protein from 26.34 ± 0.79% to 78.01 ± 1.37% for tuna white meat to its hydrolysate and 28.34 ± 1.63 to 75.17 ± 1.69% for tuna red meat to its hydrolysate, respectively. Solubilisation of protein during hydrolysis as well as removal of insoluble undigested non-protein substances after hydrolysis resulted in high protein content in hydrolysates. The protein recoveries from tuna red meat and white meat to their respective hydrolysates were 36.87% and 42.14%.

Colour of fish protein hydrolysate depends on the composition of the raw material, the hydrolysis condition and the drying method adopted. Analysis of colour using the colourimeter (Hunter Lab Colorimeter, Miniscan® XE Plus) gave an L*, a*, b* value (Table 1) revealed darker colour for TRPH than TWPH (Fig. 1).