Storage stability of the encapsulated Black Cumin (Nigella Sativa L.) seed oil powder by spray drying

Publication History
Received: 14 April 2016
Accepted: 21 May 2016
Published: 1 June 2016

Citation
Niriksha Nithin, Priya B. Storage stability of the encapsulated Black Cumin (Nigella Sativa L.) seed oil powder by spray drying. Indian Journal of Science, 2016, 23(82), 492-498
ABSTRACT

Black cumin (Nigella sativa L.) seed contains both fixed and essential oils, proteins, alkaloids and saponin. Thymoquinone, the major component of the essential oil, is responsible for most of the antioxidant activity and has anti-inflammatory, chemo-sensitization and chemo-preventive potential effects. The process parameters such as maltodextrin concentration (20 to 60%), gum Arabic concentration (20 to 60%) and drying inlet air temperature (135 to 190°C) affected the encapsulation of the black cumin seed oil. The optimum condition for the encapsulation was found to be 50% maltodextrin, 60% gum Arabic and 138°C drying inlet air temperature. Storage stability of the optimized powder was analyzed. Moisture content, water activity, peroxide value, antioxidant activity and colour were checked during the storage of the powder for a period of 30 days. There was slight increase in moisture content, water activity and peroxide value during the storage. There was insignificant degradation in antioxidant activity and colour of the powder.

Keywords : black cumin seed oil, encapsulation, optimization, stability, spray dryer

INTRODUCTION

The Black cumin (Nigella sativa L.) seed oil is used for various medicinal purposes and has many pharmacological uses. It contains both fixed and essential oils, proteins, saponins and alkaloids. The main active component present is thymoquinone which is responsible for most of the antioxidant activity of the oil. It is effective against many diseases such as cancer, cardiovascular, asthma, renal problems, diabetes etc. (Ahmed et al., 2013).

Microencapsulation can potentially offer numerous benefits to the food ingredients being encapsulated. Hygroscopic materials also can be protected from moisture and stability of ingredients that are volatile or sensitive to heat, light and oxidation can be maintained (Jafari et al., 2008). In the food industry, the most common procedure for microencapsulation is spray drying because this process is cost effective, flexible and produces particles of good quality. Microencapsulation has many applications in food industry such as to protect, isolate or control the release of a given substance which is of growing interest in many sectors of food product development. Converting a liquid into a powder allows many alternative uses of ingredients. One of the largest food applications is the encapsulation of flavours (Shahidi and Han, 1993).

During storage many chemical changes occur and lipid oxidation is the main cause of deterioration of lipid foods and cause major problem during storage. Oxidation that occurs in
edible oils relates to the loss of minor components and formation of new compounds, causing nutritional loss as well as the development of rancid and other off-flavours (Velasco et al., 2003; Sun-Waterhouse et al., 2011, Cicerale et al., 2013). Storage conditions are considered as critical variables that affect the quality of the oil and its shelf life which is attributed to lipid oxidation mechanism which leads to rancidity (Vacca et al., 2006). Hence, the aim of this study is to analyse the storage stability of the encapsulated black cumin seed oil powder and study the changes in moisture content, water activity, bulk density, colour, peroxide value and antioxidant activity during the storage of the powder.

MATERIALS AND METHODS

Materials and chemicals

Black cumin seed oil was purchased from the local market in Chennai. Gum Arabic and maltodextrin DE 18 used as wall material were obtained from SRL Pvt. Ltd, Mumbai. Tween 80 was obtained from Sigma- Aldrich, Mumbai. Analytical grade chemicals such as sodium thiosulphate, potassium iodide, DPPH was also obtained from SRL Pvt. Ltd, Mumbai.

Production of Powder

The encapsulated black cumin seed oil powder was produced with different maltodextrin concentration (20 to 60%), gum Arabic concentration (20 to 60%) and drying inlet air temperature (135 to 190°C) using a tall type spray drier ( S.M Scientech, Kolkata). The optimum conditions for the encapsulation were found to be 50% maltodextrin, 60% gum Arabic and 138°C drying inlet air temperature. The powder obtained at these conditions was packed and sealed in aluminium pouches and stored at room temperature for further studies.

Quality Analysis

Moisture content

The moisture content of the spray dried encapsulated black cumin seed oil powder was determined gravimetrically by drying in a hot air oven at 105°C until constant weight (AOAC, 2000). The moisture content was calculated using the following formulae.

\[
\text{Moisture content, d.b(\%) = } \frac{\text{Initial weight} - \text{Final weight}}{\text{Final weight}} \times 100
\]  

(1)

Water activity

Water activity was measured by using Novasina lab swift water activity meter. Triplicates were performed and the average of the water activity of the powder was recorded.

Bulk density

The powder were gently loaded into a 10 mL graduated cylinder to the 5 mL mark and weighed. The volume read directly from the cylinder was then used to calculate the bulk density.

\[
\text{Bulk density} = \frac{\text{Mass of the sample}}{\text{Volume of the sample}} \text{ g/cm}^3
\]  

(2)
Colour Analysis

The colour index of the spray dried black cumin seed oil powder was measured using a Colour Quest XE Hunter Colour Meter, based on the ‘L’ a* b* value whereas ‘L’ denotes the lightness on a 0 – 100 scale from black to white while a* and b* denote the hues which represented two colour axes with a* denoting redness (+) or greenness (−) and b* denoting yellowness (+) or blueness (−).

Peroxide value

The peroxide value of encapsulated oil powder was expressed as peroxide milli equivalent per kg oil. The sample (0.5 g) was dissolved in acetic acid-chloroform solution (3 mL, 3 : 2 v/v). After saturated potassium iodide solution was added, the mixture was left to stand for 1 min with occasional shaking. 30 mL of deionized water was added. The mixture was titrated with 0.01 N standardized sodium thiosulphate solution until the yellow iodine colour just disappeared. Starch indicator solution (0.2 mL) was added. The titration continued until the blue colour derived from the iodine just disappeared. A blank sample as reagent control was set up and carried through all the steps (AOAC, 2005)

\[
\text{Peroxide value (meq/kg) } = \frac{(S-B) \times N \times 1000}{\text{weight of the sample (g)}}
\]

Where, S and B are the titration amounts of 0.01 N sodium thio-sulphate for the sample and blank (in mL), respectively. N is the normality of sodium thiosulphate solution.

Antioxidant activity

Antioxidant activity was determined by DPPH assay as described by Sarker et al., 2006. 0.5g of sample was extracted with 10ml of 80% ethanol in a water bath for 3 hours at 45°C. The samples were then centrifuged at 5000rpm for 5min and the supernatant was separated. Varying concentrations of the sample were taken into tubes. 0.004% of DPPH solution was made and 6ml of this solution was added to each of the tubes. The tubes were incubated in dark for 30min and the OD at 517nm was taken. The percentage of DPPH scavenging was calculated as follows

\[
\% \text{DPPH radical scavenging activity} = \left(\frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}}\right) \times 100
\]

RESULTS AND DISCUSSION

Storage stability of the optimized powder

The analysis of the optimized powder was done by storing the powder in aluminum pouches at room temperature. Moisture content, water activity, bulk density, peroxide value and antioxidant activity was analyzed for 0, 7, 14, 21 and 30 days.

Table 1. Analysis of the optimized powder

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Moisture content (%) d.b.</th>
<th>Water activity</th>
<th>Bulk density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.23±0.5</td>
<td>0.315</td>
<td>0.28±0.3</td>
</tr>
<tr>
<td>7</td>
<td>2.34±0.2</td>
<td>0.326</td>
<td>0.31±0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>14</td>
<td>2.65±0.8</td>
<td>0.366</td>
<td>0.33±0.5</td>
</tr>
<tr>
<td>21</td>
<td>3.14±0.3</td>
<td>0.385</td>
<td>0.36±0.5</td>
</tr>
<tr>
<td>30</td>
<td>3.27±0.4</td>
<td>0.403</td>
<td>0.38±0.4</td>
</tr>
</tbody>
</table>

Moisture content was increased from 2.23 to 3.27% on dry basis as the storage days increased. This may be due to the sudden change in the climatic condition. There is slight increase in water activity from 0.315 to 0.403 which indicates it is microbiologically stable as the values are below 0.6. Bulk density also gradually increased during the storage.

**Peroxide value**

Peroxide value (PV) is an indicator of the oxidation level of oils and fats during processing and storage. In general, the PV of oils increased when the storage proceeded. Initial PV (2.12 meq O₂ kg⁻¹ oil) of microencapsulated black cumin seed oil powder is coherent with the study of Sun-Waterhouse et al., 2011. Peroxide value of the powder increased approximately to 13.35 meq/kg of oil during the storage period of 30 days (Fig.1). There was gradual increase till the 21st day and sudden increase towards 30th day of storage. This circumstance was possibly related with high oil content at the surface and large surface area of samples. Surface oil content increased during the storage, so that more oil was exposed to oxidation. Microencapsulation of fish oil did not exceed peroxide value of 10 meq/kg of oil due to the storage in vacuum packages (Kolanowski et al., 2005).

![Peroxide value graph](image)

**Fig. 1. Peroxide value during the storage of the optimized powder**

**Antioxidant activity**

Antioxidants in the black cumin oil absorb free radicals and appear to have a positive impact on cardiovascular and cancer ailments. For this reason, antioxidant capacity of black cumin oil must be protected during the conversion to the powder form and the storage period. Antioxidant activity decreased slightly from 61.59 to 56.55% which showed retention of the active component and good encapsulation efficiency. Sun-Waterhouse et al., 2010 also reported decrease in antioxidant activity during the storage of microencapsulated olive oil during first 30 days of storage.
Fig. 2. Antioxidant activity of the optimized black cumin seed oil powder during storage

Colour analysis

The colour analysis of the optimized black cumin seed oil powder during the storage period was studied. The values were shown in Table 2. The results showed that there was decrease in ‘L’ and increase in a*, b* value. The values of ‘L’ decreased from 79.56±0.03 to 69.56±0.04 which indicates, there is degradation in the white color of the powder. The a* values increased from 0.79±0.02 to 1.32±0.03 shows the powder was slightly red in color. The b* values increased from 19.27±0.04 to 21.89±0.05 shows powder is obtaining yellow color. This change in colour may be due to increase in the peroxide value of the oil.

Table 2. Colour analysis of the optimized black cumin seed oil powder during storage

<table>
<thead>
<tr>
<th>Days</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>79.59±0.03</td>
<td>0.79±0.05</td>
<td>23.26±0.06</td>
</tr>
<tr>
<td>7</td>
<td>77.21±0.02</td>
<td>0.97±0.04</td>
<td>25.20±0.89</td>
</tr>
<tr>
<td>14</td>
<td>74.82±0.06</td>
<td>1.12±0.03</td>
<td>26.89±0.32</td>
</tr>
<tr>
<td>21</td>
<td>71.23±0.12</td>
<td>1.24±0.02</td>
<td>27.76±0.12</td>
</tr>
<tr>
<td>30</td>
<td>69.56±0.03</td>
<td>1.32±0.06</td>
<td>28.45±0.02</td>
</tr>
</tbody>
</table>

Conclusion

The storage stability indicates the shelf life of the product. The ambient storage studies of optimized spray dried black cumin seed oil powder showed increase in moisture content, water activity and bulk density. There was no drastic change in peroxide value initially. There was drastic increase after the 21st day and increased upto 13.35 meq/kg. The antioxidant activity was also retained and there was no much reduction due to good microencapsulation efficiency. The colour values decreased gradually from whiteness to yellowness. Hence the spray dried black cumin seed oil powder can be stored upto 30 days at room temperature and can be used in food fortification. The analysis of storage stability will be extended for six months in future.
REFERENCES


