Increase of the *in vitro* bioaccessibility of carotenoids through delivering of inclusion complexes
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HEALTH BENEFITS DERIVED FROM CAROTENOIDS

Provitamin A

β-carotene

Functions

Actions

Consumption of foods containing carotenoids is associated with a lower risk of developing degenerative processes

Associations

Antioxidants

Immuno enhancers

Gap junction communications

β-carotene

lycopene

zeaxanthin

lutein

astaxanthin

HEALTH BENEFITS DERIVED FROM CAROTENOIDS
Interest in the screening of bioavailability has increased for different reasons:

1. Existence of undernourished population

2. Epidemiological studies have associated between consumption of carotenoid-rich fruits and vegetables to a lower risk of developing degenerative diseases

3. Development of food products with added nutritional value

4. Food legislation concerning functional foods
A MULTIFACTORIAL SYSTEM EFFECTS
CAROTENOID ASSIMILATION

⇒ Carotenoids are fat soluble compounds
1. Liberation from food matrix
2. Incorporation to mixed micelles
3. Absorption by epithelial cells through simple/facilitated diffusion mechanisms

⇒ Absorption efficiency is relatively low from fruits and vegetables
1. Dietary factors exert great effects on absorption
2. Increase of absorption efficiency from processed fruits and vegetables (homogenization and thermal processing)
FOOD FORMULATION WITH IMPROVED CAROTENOID ABSORPTION

- If addition of carotenoids to food formulae is aimed to increase the nutritional value and to claim health benefits
  1. Bioaccessibility should be a design criteria in food formulation
  2. Improvement of nutritional quality of food product

- Different approaches could be considered
  1. Emulsion, encapsulation, inclusion complexes
  2. Selection and formulation of the emulsifiers or encapsulating agents should be optimized
  3. Demonstrate its efficiency
AIM OF THE STUDY

Estimation of the bioaccessibility of dietary carotenoids reached when they are delivered as inclusion complexes

1. Dietary carotenoids ($\beta$-carotene, lutein and lycopene) were formulated as inclusion complexes with $\beta$-cyclodextrin or as emulsions

2. BBMV preparations were used as the *in vitro* model to assay carotenoid uptake. BBMV were isolated from pig small intestine and characterized by determining protein content and sucrase activity

3. Estimation of carotenoid assimilation from both formulations and comparison of absorption efficiency
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RESULTS

Absorption efficiency depends on carotenoid type independently of delivering method

Delivery method: Carotenoid emulsion (C. E.)

![Graph showing absorption efficiency for different carotenoids at various concentrations.]

- Carotenoid concentration at the donor solution:
  - 0.5 μM
  - 1.0 μM
  - 2.5 μM

- Absorption (pmol/mg protein)
  - β-carotene
  - Lutein
  - Lycopene
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RESULTS

.Absorption efficiency depends on carotenoid type independently of delivering method

Delivery method: Carotenoid inclusion complex (C. I. C.)

![Graph showing absorption efficiency of different carotenoids at varying concentrations.](image)

- **β-carotene**
  - 0.5 μM
  - 1.0 μM
  - 2.5 μM

- **Lutein**
  - 0.5 μM
  - 1.0 μM
  - 2.5 μM

- **Lycopene**
  - 0.5 μM
  - 1.0 μM
  - 2.5 μM
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**RESULTS**

Does delivery of carotenoid inclusion complex mean an increase on absorption efficiency?

Absorption rate in pmol/(mg protein x min)

<table>
<thead>
<tr>
<th></th>
<th>β-carotene</th>
<th>lutein</th>
<th>lycopene</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 μM</td>
<td>32.9</td>
<td>20.1</td>
<td>9.85</td>
</tr>
<tr>
<td>1.0 μM</td>
<td>65.3</td>
<td>36.6</td>
<td>26.9</td>
</tr>
<tr>
<td>2.5 μM</td>
<td>70.7</td>
<td>106</td>
<td>30.1</td>
</tr>
</tbody>
</table>
RESULTS

Solubility of carotenoids is a rate-limiting step of absorption.

Dissolution kinetics of the complex is enhanced at high concentrations and depends on binding constant of the complex.

\[ \text{Dissolution of the complex} \]

\[ K_{\text{complexation}} \]

Assimilation:
Passive or facilitated diffusion
CONCLUSIONS

- Molecular characteristics of carotenoid modulate absorption efficiency independently of the delivery strategy

- Absorption of carotenoids inclusion complex exhibits no-saturation effect at the experimental concentrations

- De-complexation process is significantly improved at the highest concentration, enhancing the efficiency of absorption in comparison with that of the carotenoid emulsions
ACKNOWLEDGMENTS

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THANKS FOR YOUR ATTENTION!