Note

Unchanged Intestinal Absorption in Rats Fed a High Sweet Paprika-Containing Diet

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Summary The absorption rate of radiolabelled nutrients (22Na, 45Ca, [35S]methionine, [3H]leucine) was investigated in vivo in Sprague-Dawley rats at the end of a feeding period of 135 days on a semisynthetic diet containing 32% sweet paprika powder. No effect was seen on the intestinal absorption of these compounds, nor on the nutritive experimental parameters in these animals.

Key Words β-carotene, Na absorption, Ca absorption, methionine absorption, leucine absorption, intestinal absorption, paprika, chronically fed rats

Hungarian scientists played a pioneer role in researching the biological and nutritional effects of red pepper (paprika; Capsicum annuum L.; (1-4)).

In the nutrition and physiological research, two distinct kinds of ground red pepper are employed: the first of them, with high capsaicin content, is the pungent or hot paprika. The second one, called sweet paprika, contains capsaicin in such a low concentration (<0.9 mg/100 g), that it is neither sensed in consumption, nor exerts any irritative effect.

Many papers have dealt with the physiological or pharmacological role of capsaicin, or the capsaicin-containing hot paprika (5, 6). Conversely, the literature of sweet paprika in this field is very scarce, in spite of its high content of β-carotene, carotenoid, trace elements and other bioactive substances.

Oral administration of red pepper or its extract may exert indirect effects with nutritive consequences, as the influence of small intestinal peristalsis and oroecal transit time (7), and due to it, obviously, enhanced intestinal absorption. Since, little is known about the biological effects of long-term oral administration of red (sweet) paprika powder, this study was conducted to measure the intestinal absorption of various radiolabelled compounds in rats in vivo.

Materials and methods

Animals. Sprague-Dawley CFY rats were used, their final (adult) body weight varied between 200-230 g. 8 male and 8 female rats formed one group.
Feeding of the diet started at 30 days of age (weaning time) and lasted 135 days.

**Diets.** 1. Semisynthetic basic diet/S/, given ad libitum, contained the following ingredients: 6.8% casein, 15.4% powdered milk, 17.2% flour, 2.4% sugar, 5.2% fat, 41% starch, 11.6% alfalfa roughage (as a source of crude fiber), 0.4% vitamin and mineral premix.

2. Semisynthetic diet supplemented with sweet paprika /SP diet/, consists of 20.6% starch and 32% ground paprika, all other ingredients were identical with S diet. The mean daily intake from β-carotene: 10 mg/kg b.w., from carotenoids: 100 mg/kg b.w., were estimated from the analysis data of paprika powder.

The two semisynthetic diets (S and SP) were balanced: according to the chemical analyses, the carbohydrate and crude fibre content of paprika was equilized by a higher starch content and an alfalfa roughage replacement in S diet. Both diets had a coarse consistency to avoid the possible aspiration of a pulverized diet and spoilage from the self-feeders. All cages were supplied with wood sticks for nibbling to ensure normal tooth wearing. Strict nutritive identity, however, can not be expressed due to the lack of data on the digestibility of paprika. The nutritional adequacy of the diets with the requirements, as well as their similar nutritive values, were confirmed by the comparable food intake, growth curve, final body weight, food efficiency ratio, etc.

The investigation of the absorption rate of labelled nutrients was preceded by a chronic feeding period of 135 days.

**Radioisotope labelled nutrients.** NaCl: 22-Na (Amersham) 18 kBq/sac, CaCl$_2$: $^{45}$Ca, 300 μg, 37 kBq/sac, $^{35}$S labelled methionine: 25 μM = 37 kBq, DL-[3H]leucine: 25 μM = 185 kBq/sac.

**Intestinal absorption.** Intestinal absorption was determined by the method of Winter et al. (8). The animals were fasted for 18 h and anesthetized with pentobarbital sodium. The abdominal cavity was opened and on the proximal part of duodenum, a 12–15 cm long sac was formed by two ligatures. The radiolabelled material was added in 0.5 ml volume into this sac and the abdomen was temporarily closed. Twenty minutes later, the abdomen was reopened, the ligated intestinal segment removed, and its contents washed out with 20 ml of distilled water. The radioactivity of these outwashed solutions was determined.

**Measurement of radioactivity.** γ activity was measured in a well-type NaI scintillation crystal counter (Gamma), μ activity was counted in Bray's solution in an Intertechnique liquid scintillation counter. Calculations: Absorbed activities are expressed as a percentage of administered activities. Statistical analyses were performed from the measured dpm values by Student’s t-test and SD values are presented.

**Carotenoids and vitamin A determination.** vitamin A in the liver was determined by the method of Moor (9) and from the sera by that of Neeld and Pearson (10). Carotenoids in various homogenized organs were checked by thin layer chromatography (11). Briefly: the samples were saponified by KOH, washed and dried under nitrogen atmosphere, dissolved in benzene and chromatographed on
Polygram-SIL-G (Macherey-Nagel and Co., BRD), using a petrolether-benzene-acetic acid-acetone system, eluated in methanol and the colour was detected by spectrophotometry.

Autopsy. Gross pathological examination and histological evaluation of organs (gastrointestinal tract, lung, liver, kidney) followed the feeding study.

Results
The daily food intake of rats fed ad libitum was practically unaffected by the high sweet paprika content of SP diet (the daily mean food intake was 20.8 g/rat and 18.7 g/rat in S and SP groups, respectively). In the body weights of the paprika-fed groups no significant changes were observed (Fig. 1). The animals, after a short accommodation period, willingly ate the paprika-containing diet.

For the evaluation of the changes in nutritional status of carotenoids in rats after ingestion for a long period, the vitamin A content in the serum and liver were determined. The data in Table 1 show that vitamin A content in the liver and its level in the sera were significantly increased in SP-fed rats ($p \leq 0.01$, and $p \approx 0.05$, resp.). At the end of the feeding experiment, the distribution of deposited carotenoids in various organs of the sacrificed rats was qualitated by thin layer chromatography (liver, kidney, heart, mammary gland, muscle, skin, serum, urine, feces). Both yellow and red carotenoids could be detected in the various organs of rats in the SP group.

The absorption rate of labelled nutrients is summarized in Table 2. Calcium and sodium absorption in rats kept on the SP diet was similar with those fed the S diet (controls).

Fig. 1. Body weight curves of rats kept on semisynthetic diet (S) and supplemented with sweet paprika (SP).

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Table 1. Vitamin A content of serum and liver of rats fed on a semisynthetic diet with (SP) or without (S) paprika.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Vitamin A content (M±SD)</th>
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<tbody>
<tr>
<td></td>
<td>Serum IU/100 ml</td>
<td>Liver IU/g liver</td>
</tr>
<tr>
<td>S</td>
<td>155±110</td>
<td>538±183</td>
</tr>
<tr>
<td>SP</td>
<td>280±127</td>
<td>1,057±323</td>
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Table 2. Absorption rate of radiolabelled nutrients in rats kept on a semisynthetic diet without (S) or with paprika (SP).

<table>
<thead>
<tr>
<th>Labelled nutrient</th>
<th>Group</th>
<th>Diet: S absorbed in % of administered activity (M±SD)</th>
<th>Diet: SP absorbed in % of administered activity (M±SD)</th>
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</thead>
<tbody>
<tr>
<td>$^{45}$Ca</td>
<td>m</td>
<td>25.6±11.1</td>
<td>24.4±13.5</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>19.4±8.9</td>
<td>15.2±7.7</td>
</tr>
<tr>
<td>$^{22}$Na</td>
<td>m</td>
<td>89.1±5.6</td>
<td>91.4±4.5</td>
</tr>
<tr>
<td>[$^{35}$S]Methionine</td>
<td>m</td>
<td>33.2±12.2</td>
<td>35.4±9.5</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>45.6±8.4</td>
<td>43.4±10.8</td>
</tr>
<tr>
<td>[$^{3}$H]Leucine</td>
<td>f</td>
<td>56.0±8.4</td>
<td>41.9±12.1*</td>
</tr>
</tbody>
</table>

m: male  f: female.

* $p<0.05$.

[$^{35}$S]Methionine absorption was not changed significantly in paprika-fed rats. In $^{3}$H leucine absorption, the leucine absorption was found to have decreased slightly but significantly in female rats ($p<0.05$).

Gross and histopathological analysis did not reveal any significant difference between the two groups, and intestinal epithelium remained intact.

Discussion

Red pepper is a widely used food, either in the form of spice or consumed as a vegetable. $\beta$-Carotene, administered chronically in large doses as a chemopreventive drug for tumour development, has increasing importance (12, 13) and its protective effect against atherosclerosis was also demonstrated (14, 15). Sweet paprika powder contains $\beta$-carotene at 200–950 mg/kg, and carotenoids at 3.0–12.1 g/kg concentration resp. (16), so it could be regarded as an abundant source of these substances. $\beta$-Carotene of paprika has an advantage over other natural food items in bioeffectiveness (17).

The increased vitamin A concentration in the liver and sera in the SP group, as well as the distribution of the deposited carotenoids in various organs did prove a higher rate in pigment absorption (including $\beta$-carotene) from a long-term feeding with a diet (SP diet) containing abundant quantities of carotenoids.

The main carotenoid components of red pigments are capsorubin and capsanthin, the major yellow pigment constituents are: zeaxanthin, lutein, cryptoxanthin.
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and \( \beta \)-carotene (18).

Although the details results of our analyses have not been published yet, it is noteworthy that the liver extracts show a sex difference in the colour of carotenoid deposits.

Capsaicin administration influenced the intestinal absorption of several nutrients either directly (19, 20), or indirectly (21). The long-term intake of diet containing a high concentration of sweet paprika powder had practically no effect on the intestinal absorption of different nutrients. Furthermore, no changes were observed in the development of the animals and no toxic effect was found.

Sweet paprika, as \( \beta \)-carotene source —from the aspect of enteral absorption and nutrient utilization— can be used without any toxic effect; however, since the experiments were performed on rats, the conclusions are valid only for this animal. The effect of carotenoids on humans is a topic for further investigations.

REFERENCES


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