Caseinphosphopeptides (CPP) in Feces and Contents in Digestive Tract of Rats Fed Casein and CPP Preparations

Takanori Kasai, Ryo Iwasaki, Miyuki Tanaka, and Shuhachi Kiriyama
Department of Bioscience and Chemistry, Faculty of Agriculture, Hokkaido University, Sapporo 060, Japan
Received May 26, 1994

A part of caseinphosphopeptides (CPP) formed during the digestion of casein in the small intestine of rats fed casein was not hydrolyzed in the digestive tract, but was excreted into the feces. Amino acid compositions of CPP fraction of feces for wk 1 and 2 were almost identical. The residual CPP in the feces expressed by the rate of bound phosphoserine in the CPP fraction of feces to bound phosphoserine ingested (phosphoserine-CPP/phosphoserine-ingested rate) in the ileum was the highest 4 h after the start of feeding of casein but decreased significantly after 10 h. No significant difference was observed in the rates of contents in jejunum, cecum, and colon between 4 h and 10 h after the start of feeding. No significant difference was observed in the phosphoserine-CPP/phosphoserine-ingested rate in contents of any part of the digestive tract between 50% casein and 75% CPP I (a commercial CPP product with nearly the same amino acid composition as that of casein) 4 h and 10 h after the start of feeding, except for the cecum 4 h after the start of feeding. No significant difference in phosphoserine-CPP/phosphoserine-ingested rate was observed in the contents of any part of digestive tract between the groups fed 50% casein and 5% CPP III + 45% soybean protein isolate (SPI) 4 h or 10 h after the start of feeding (CPP III is a commercial CPP product containing nearly 8 times the concentration of phosphoserine as CPP I). The phosphoserine-CPP/phosphoserine-ingested rate of the 5% CPP I +45% SPI group was significantly higher in any part of digestive tract than those of 50% casein and 5% CPP III +45% SPI groups 4 h after the start of feeding.

Milk and milk products have been reported to be excellent sources of calcium not only due to their high calcium concentration, but also to the higher bioavailability of this mineral. The high calcium availability in milk has been attributed to lactose and caseinphosphopeptides (CPP) formed during digestion of casein in the small intestine.1–8 CPP have been shown to form soluble complexes with calcium and inhibit precipitation of calcium phosphate resulting in an increase in soluble calcium in the lower small intestine.1,5–12 Although the potential importance of CPP in enhancing calcium absorption from the small intestine has been proposed, the fate of CPP accumulated in the most distal part of small intestine was not known until we found them in the feces of rats fed a casein diet, indicating that at least a part of CPP formed in the small intestine was not hydrolyzed in the digestive tract, but was excreted in feces.13 This paper describes the amounts of CPP excreted in the feces of rats fed casein diets and compares the distribution pattern of CPP in the small intestine, cecum, and colon of rats fed casein with those fed a commercial CPP product prepared by tryptic digestion of casein.

Materials and Methods

Because of the diversity in CPP molecules in the feces13 and contents in digestive tract (ref. 14 and our unpublished data) of rats fed a casein diet, it was difficult to measure the total amount of CPP in feces and contents of digestive tract. Therefore, bound phosphopeptide contents in CPP fraction were measured. Since the molar ratio of phosphorus to serine in CPP fraction of feces was 0.96 and all serine residues in CPP so far found in feces were phosphorylated,13 it was considered that serine residues in CPP fraction of contents in digestive tract before being excreted into feces were also phosphorylated and serine in the hydrolyzate of CPP fraction could be taken as serine derived from phosphoserine residues of CPP.

CPP in feces of rats fed casein (Experiment 1). Experiment 1 was done to measure the amount of CPP excreted in the feces of rats fed a casein diet.

a. Animals and diet. Male weaning Sprague-Dawley rats (mean body weight 54 g. Japan SLC) were individually housed in suspended cages in a temperature controlled room (23 ± 1°C) with 12 h of light (0800–2000 h). After being fed a 25% casein diet for 5 days, each rat was transferred to a metabolic cage to collect feces and allowed free access to the same diet for 14 days. The composition of the experimental diet is given in Table 1. Feces of each rat were collected every week, washed with a small amount of hot water to remove urine, food, and other contaminants adhering to the feces, and lyophilized.

b. Measurement of CPP in feces. Usual amino acids and peptides are exchanged by a strongly acidic cation exchange resin (H+ form), but CPP are not retained by the resin because of their strong acidity.13 Therefore, the extract of the feces was put on a Dowex 50 (H+ form) column and the CPP fraction obtained as the effluent from the column was used to measure bound phosphoserine content. The rate of bound phosphoserine in CPP fraction to bound phosphoserine ingested was calculated and expressed as the phosphoserine-CPP/phosphoserine-ingested rate (%). Lyophilized feces were pulverized and extracted with 3% sulfosalicylic acid (2 ml/g feces) for 2 days at room temperature. One ml of the filtrate of the extract was diluted to 100 ml with water and 10 ml of the diluted extract was passed through a Dowex 50 (H+, 1 ml) column, which was then washed with water (10 ml). The effluent and washings were combined and concentrated to dryness in vacuo. A sample of the evaporation residue was hydrolyzed (6 N HCl, 110°C, 20h, in a sealed tube) and the amino acid composition of the hydrolysate was analyzed as phenylthiobutyrate derivatives by HPLC constructed with a Waters 600 Multisolute Delivery System (Waters Association) and Wakopak WS-PTC column (4.0 × 200mm, Wako Pure Chemical Industries).15,16

Distribution of CPP in digestive tract of rats fed casein (Experiment 2). Although the accumulation of CPP in the most distal part of small intestine of rats fed casein has been clearly demonstrated, the behavior of CPP in the cecum and colon has not been clarified. The objective of experiment

Abbreviations: CPP, caseinphosphopeptides; SPI, soybean protein isolate.
Table 1. Composition of the Experimental Diets for Experiments 1 to 4

<table>
<thead>
<tr>
<th></th>
<th>Diets</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Casein</td>
<td></td>
<td>Casein</td>
<td>CPP I</td>
<td>CPP III</td>
<td>SPI</td>
<td>SPI</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>g/kg diet</td>
<td>+45%</td>
<td>+45%</td>
<td>β</td>
<td>α</td>
</tr>
</tbody>
</table>

2 was to analyze the distribution of CPP in the small intestine, cecum, and colon after ingestion of casein. Since only a small part of the unabsorbed residue of food is excreted during 24 h after feeding in rats, 17 contents of digestive tract were collected 4 h and 10 h after the start of feeding to discover the digestibility of CPP in the digestive tract before it was excreted into the feces.

a. Distribution of CPP in digestive tract. Male weanling rats of the Sprague-Dawley strain (mean body weight 93 g) were fed 25% soybean protein isolate (SPI) (Fujipro, Fuji Oil Co.) for 6 days. They deprived of food for 1 day, divided into 2 groups of six rats each (mean body weight 123 g) and fed 2 g of a 25% casein diet. Rats of one group were killed by exanguination under anesthesia (Nembutal, 5 mg/100 g body weight) 4 h after the start of feeding. Rats in the other groups were killed 10 h after the start of feeding. No rat excreted feces during this period. The small intestine between the Treitz ligament and ileocecal junction was excised and divided into proximal (jejunum) and distal (ileum) parts at the midpoints. The contents of each part were flushed with ice-cold water (10 ml x 2). The cecum was dissected with scissors and the contents were washed out with ice-cold water. The contents of the colon were flushed out with ice-cold water (5 ml x 3). Each preparation was lyophilized.

b. Distribution of CPP in digestive tract. Lyophilized contents in each part of the digestive tract were pulverized and extracted with 5 ml of 3% sulfosalicylic acid. A sample of the extract was treated by the same procedures as those for the extract of feces as described above. Bound phosphoserine of the CPP fraction in each sample was measured by the same method as for the feces extract. The phosphoserine-CPP phosphoserine-ingested rate in the digestive tract was calculated as described in experiment 1.

Distribution of CPP in digestive tract of rats fed casein and CPP preparation 1 (Experiment 3). Experiments 1 and 2 showed that at least some of CPP accumulated in the distal part of small intestine of rats fed casein were not metabolized in the cecum and colon, but excreted in feces. Experiment 3 was done to compare the distribution patterns of CPP in the digestive tract of rats fed casein with those fed a CPP commercial preparation (CPP I or CPP III, Meiji Seika Kaisha). Preparation methods of CPP I and CPP III were as follows: 18, 19. CPP I was prepared by spray drying of tryptic digests of casein and thus had nearly the same amino acid composition as that of casein. CPP III was prepared from fraction CTP. The digestible part of casein was centrifuged and the supernatant was mixed with calcium and ethanol to precipitate CPP. The precipitate formed was collected and dried to prepare CPP III. CPP III contained about eight times the concentration of phosphoserine of CPP I. The phosphoserine contents of CPP I and CPP III were measured by HPLC, as described in experiment 1, were 0.16 and 1.22 mmol/g, respectively.

Male weanling Sprague-Dawley rats (mean body weight 102 g) were fed 25% SPI for 6 days and divided into 4 groups with 6 rats each (mean body weight 137.5 g). They were deprived of food for 1 day and two groups were fed 2 g of the 50% casein diet. The other two groups were fed 2 g of the 50% CPP I diet. The compositions of the experimental diets are shown in Table 1. The concentration of casein in the diet was increased to 50% to isolate and characterize CPP in the digestive tract because the amount of CPP found in the digestive tract of rats fed 25% casein was very low in experiment 2. However, CPP in the digestive tract could not be characterized in this experiment. The contents in each part of digestive tract were collected 4 h and 10 h after the start of feeding and bound phosphoserine in the CPP fraction in each sample were measured as in experiment 2. However, contents in stomach were collected this time and those in jejunum were not collected because the CPP content in the jejunum was low in experiment 2.

Distribution of CPP in digestive tract of rats fed casein and CPP preparation 2 (Experiment 4). Because distribution patterns of CPP in the digestive tract of rats fed 50% casein and 50% CPP I diets were similar, as shown in Results, the distribution of CPP in digestive tract of rats fed 50% casein was compared with that fed 5% CPP III + 45% SPI diet in experiment 4. Since the phosphoserine concentration in CPP III was nearly 8 times higher than that in CPP I, as described above, the CPP III concentration in the diet was made up to 5% and supplemented with SPI to adjust the protein concentration to 50% in this experiment. The 3rd group was fed 5% CPP I supplemented with 45% SPI to compare the CPP distribution in the digestive tract between low CPP and high CPP diets.

Male weanling Sprague-Dawley rats (mean body weight 104 g) were fed 25% SPI for 6 days and divided into 6 groups with 6 rats each (mean body weight 146.6 g). They were starved for 1 day. Groups 1 and 2 were fed 2 g of 50% casein diet, groups 3 and 4 were fed 5% CPP III + 45% SPI diet, and groups 5 and 6 were fed 5% CPP I + 45% SPI diet. The composition of the experimental diets are shown in Table 1. The contents of each part of the digestive tract were collected in groups 1, 3, and 5 4 h after the start of feeding and groups 2, 4, and 6 10 h after the start of feeding, and bound phosphoserine in the CPP fraction in each sample was measured as in experiment 3.

The study protocol was approved by the Hokkaido University Animal Use Committee, and animals were maintained in accordance with the guidelines for the care and use of laboratory animals, Hokkaido University.

Statistical analysis. All data were tested by Student's t-test (experiments 1 to 3) or analyzed by ANOVA and tested by Duncan's multiple range test (experiment 4) to find whether differences between means were significant (p < 0.05). Values in the text are means ± SEM (n = 6).

Results

The phosphoserine content of the commercial casein used in this study (Alacid, New Zealand Dairy Board) which contained 11% water by weight, calculated from the composition of the components in casein, is 0.2 mmol/g. The composition of the components in casein is [ratio (%), molecular weight, and number of phosphoserine residues in each component]: α1 (35.6, 23,000, and 8), α2 (9.9, 23,000, and 13), β (33.6, 24,100, and 5), and κ (11.9, 19,000, and 1) (γ-casein does not contain a phosphoserine residue). 19
Experiment 1
The bound phosphoserine content in the CPP fraction (effluent from a column of strongly acidic cation exchange resin in H⁺ form) of the feces of rats fed 25% casein were 69.0 ± 14.8 μmol/g dried feces and 79.7 ± 13.3 for wk 1 and 2, respectively. Phosphoserine-CPP/phosphoserine-ingested rate (%) in feces were 1.4 ± 0.3 and 2.2 ± 0.3 for wk 1 and 2, respectively. The relative amino acid composition in the CPP fraction of feces during wk 1 and 2 are shown in Table II. Amino acid composition was expressed with serum content as 4, because both two CPP identified in feces of rats fed 25% casein contained 4 phosphoserine residues.13) The amino acid compositions of CPP fractions in feces for wk 1 and 2 were almost identical.

Experiment 2
A fair amount of food remained in the stomach 4h after the start of feeding and, although not measured, the amount of residual food in the stomach decreased considerably during the next 6h. The phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract in experiment 2 is shown in Table III. The rate was the highest in the ileum 4h after the start of feeding, but the rate decreased significantly after 10h compared to that 4h after the start of feeding. No significant difference was recognized in phosphoserine-CPP/phosphoserine-ingested rate between 4h and 10h after

Table II. Amino Acid Composition of the CPP Fraction in Feces of Rats fed 25% Casein (Experiment 1)

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Week 1</th>
<th>Week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asp</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Ser</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Thr</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Glu</td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Pro</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Gly</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Ala</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Val</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Ile</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Leu</td>
<td>0.1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

1 Single observation with a Model 835 Hitachi high-speed amino acid analyzer, using Hitachi 2619 custom ion-exchange resin (2.6 mm × 250 mm) and MCI® 835-kit (both Mitsubishi Chemical Industries). Amino acid composition of CPP fraction was expressed with serum content as 4.0, because both of two CPP identified in feces of rats fed 25% casein contained 4 phosphoserine residues.13)

Table III. The Rate (%) of Bound Phosphoserine in the CPP Fraction to Bound Phosphoserine Ingested (Phosphoserine-CPP/Phosphoserine-ingested Rate) in the Digestive Tract of Rats Fed 25% Casein 4h and 10h after the Start of Feeding (Experiment 2)

<table>
<thead>
<tr>
<th>Tract</th>
<th>4h</th>
<th>10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jejunum</td>
<td>0.6 ± 0.1</td>
<td>0.5 ± 0.1</td>
</tr>
<tr>
<td>Ileum</td>
<td>5.2 ± 1.0</td>
<td>1.4 ± 0.2</td>
</tr>
<tr>
<td>Cecum</td>
<td>3.0 ± 0.6</td>
<td>3.3 ± 0.5</td>
</tr>
<tr>
<td>Colon</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.1</td>
</tr>
</tbody>
</table>

1 Values are means ± SEM (n=6).
* Significantly different from the 4h value by Student’s t-test (p < 0.05).

Table IV. The Rate (%) of Bound Phosphoserine in the CPP Fraction to Bound Phosphoserine Ingested (Phosphoserine-CPP/Phosphoserine-ingested Rate) in the Digestive Tract of Rats Fed 50% Casein, 50% CPP I, 5% CPP III, 5% CPP I + 45% SPI, and 5% CPP I + 45% SPI 4h and 10h after the Start of Feeding (Experiments 3 and 4)

<table>
<thead>
<tr>
<th>Tract</th>
<th>4h (%)</th>
<th>10h (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td>1.8 ± 0.4</td>
<td>0.9 ± 0.3</td>
</tr>
<tr>
<td>Ileum</td>
<td>2.8 ± 0.6</td>
<td>0.9 ± 0.2</td>
</tr>
<tr>
<td>Cecum</td>
<td>1.9 ± 0.3</td>
<td>1.1 ± 0.2</td>
</tr>
<tr>
<td>Colon</td>
<td>0.2 ± 0.1</td>
<td>0.3 ± 0.1</td>
</tr>
<tr>
<td>Stomach</td>
<td>3.7 ± 0.3</td>
<td>15 ± 1.4*</td>
</tr>
<tr>
<td>Ileum</td>
<td>2.0 ± 0.3</td>
<td>11 ± 1.9*</td>
</tr>
<tr>
<td>Cecum</td>
<td>2.2 ± 0.4b</td>
<td>13 ± 1.1*</td>
</tr>
<tr>
<td>Colon</td>
<td>0.5 ± 0.1b</td>
<td>23 ± 18*</td>
</tr>
</tbody>
</table>

2 Commercial product of caseinphosphopeptides, Meiji Seika Kaisha. Contained about eight times the concentration of phosphoserine compared with CPP I.
3 Soybean protein isolate, Fujipro, Fuji Oil Co.
4 Values are means ± SEM (n=6).
* Significantly different than the 50% Casein value in the same time course by Student’s t-test (p < 0.05).
* Values in a row with a different superscript are significantly different among three diet groups in the same course by Duncan’s multiple range test after ANOVA (p < 0.05).
the start of feeding in the jejunum, cecum or colon.

**Experiment 3**

The phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract in experiments 3 and 4 is summarized in Table IV. No significant difference was observed in the phosphoserine-CPP/phosphoserine-ingested rate between the 50% casein and 50% CPP I groups except for the cecum, where the rate of 50% casein group was significantly higher than that of 50% CPP I group 4 h after the start of feeding. The ileum had the highest phosphoserine-CPP/phosphoserine-ingested rate 4 h after the start of feeding as in experiment 2. The stomachs of both groups still contained a high phosphoserine-CPP/phosphoserine-ingested rate 4 h after the start of feeding. After 10 h, no significant difference in the phosphoserine-CPP/phosphoserine-ingested rate was observed between the two diet groups except for the stomach. The stomach of the 50% casein group had a significantly higher phosphoserine-CPP/phosphoserine-ingested rate than the 50% CPP I group.

**Experiment 4**

No significant difference in the phosphoserine-CPP/phosphoserine-ingested rate was observed in any part of the digestive tract between 50% casein and 5% CPP III + 45% SPI groups both 4 h and 10 h after the start of feeding. The phosphoserine-CPP/phosphoserine-ingested rate in the cecum and colon was close to constant compared to those in stomach and ileum where the rate decreased with time after feeding, as in experiments 2 and 3. The phosphoserine-CPP/phosphoserine-ingested rate of the 5% CPP I + 45% SPI group was significantly higher in all parts of the digestive tract 4 h after the start of feeding and was still significantly higher in the ileum and colon after 10 h compared with the 50% casein and 5% CPP III + 45% SPI groups. Unchanged phosphoserine-CPP/phosphoserine-ingested rate in the ileum and a decrease in the rate in the cecum and colon with time after feeding of 5% CPP I + 45% SPI diet were also in contrast to those values in the 50% casein and 5% CPP III + 45% SPI groups.

**Discussion**

CPP, which is formed from casein by enzymatic hydrolysis and accumulates in the most distal part of the small intestine, contains phosphoryl residues that bind calcium and thus form soluble complexes, preventing the amorphous or crystalline precipitation of calcium phosphate.\(^1,5-12\) CPP are now industrially produced by the tryptic hydrolysis of bovine casein and sold as useful food-stuffs.\(^1,4,18\)

The behavior of the CPP beyond the ileum, however, had not been known until we found some CPP in the feces of rats fed a casein diet and characterized two of them, indicating that at least some of the CPP formed in the small intestine resisted the hydrolysis by digestive enzymes and enteric bacteria in the digestive tract.\(^13\) These experiments were done to measure the amount of CPP in feces and in the contents of the digestive tract of rats fed casein and to compare the CPP patterns in the digestive tract of rats fed casein with those fed commercially produced CPP. However, it was difficult to measure the amount of CPP in feces and contents of digestive tract because of the diversity in the CPP molecules. Therefore, phosphoserine in the CPP fraction which was not retained by strongly acidic ion exchange resin was measured,\(^13\) and the phosphoserine-CPP/phosphoserine-ingested rate in feces and the contents in each part of the digestive tract was calculated. The precise amount of residual CPP in digestive tract was not obtained in this experiment, because an absorption marker was not included in the diets and the recovery of water-insoluble CPP was insufficient, but it was shown that CPP existed also in cecum and colon of rats fed casein or CPP diets and the distribution pattern of CPP in the contents of digestive tract of rats fed the diet containing CPP was not distinguishable from that of rats fed casein that contained a comparable amount of phosphoserine as that of the CPP diet.

In experiment 1, the phosphoserine-CPP/phosphoserine-ingested rate (％) in the feces of rats fed 25％ casein was 1.4 and 2.2 during wk 1 and 2, respectively, and the amino acid composition of the CPP fraction in feces for wk 1 and 2 were nearly identical, indicating that the patterns of casein digestion and the appearance of CPP in digestive tract of rats fed casein were constant during the experimental period (Table II). The rates (％, g/g) of CPP in feces to casein ingested were calculated to be 0.13 and 0.21 for wk 1 and 2, respectively, by assuming that CPP in feces contained 4 phosphoserine residues and their average molecular weight was 1,500, because two CPP which were characterized in the feces contained 4 phosphoserine residues and their molecular weights were 1,128 and 1,366.\(^13\) Therefore, CPP excreted in the feces comprised 3％-10％ of non-absorbable casein because the absorption ratio of casein by rats is 96％-98％.

Experiment 2 confirmed that CPP were present not only in the small intestine, but also in the cecum and colon (Table III). It has been suggested that CPP is of great importance in enhancing calcium absorption from the small intestine,\(^1,2,6,8-10\) but CCP may also enhance calcium absorption in the digestive tract beyond the small intestine because it was demonstrated in this experiment that CPP existed in the digestive tract beyond ileum.

It was expected from experiment 3 that the ability of CPP I, a commercial product prepared by spray drying of a tryptic digest of casein,\(^18\) to prevent precipitation of calcium phosphate by forming soluble complexes with calcium in the digestive tract was nearly equal to that of casein, because the phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract of rats fed 50％ CPP I was not significantly different from those fed 50％ casein (Table IV).

Phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract of rats fed 5％ CPP III + 45％ SPI was also not significantly different from those fed 50％ casein (experiment 4, Table IV). It was shown from experiments 3 and 4 that the phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract of rats fed the diet containing CPP was not distinguishable from that of rats fed casein which contained a comparable amount of phosphoserine as that of the CPP diet. However, experiment 4 showed that the phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract of rats fed 5％ CPP I was significantly higher than those fed 5％ CPP III and 50％ casein. Because the phosphoserine-CPP/phosphoserine-ingested rate in the digestive tract of rats fed 25％ casein...
in experiment 2 was also higher than those fed 50% casein in experiments 3 and 4 (Tables III and IV), the rate in the digestive tract of rats fed lower concentration of CPP or casein seems to be higher than that of rats fed a higher amount of CPP or casein, however, the reason for the difference is unclear.

Although it has been well established that CPP binds calcium to form soluble complexes, preventing precipitation of calcium phosphate, it is still controversial whether CPP enhance intestinal calcium absorption. Many studies have reported that CPP increase intestinal absorption of calcium in rats and chicks but phosphopeptides have also been reported to have no effect on calcium absorption in rats. Studies on the isolation of CPP from the feces of rats fed a casein diet, their ability to prevent precipitation of calcium phosphate and effect on calcium absorption in rats, especially from the digestive tract beyond the small intestine where they are formed, are in progress.

References