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Effect of nanometer pearl powder on calcium absorption and utilization in rats

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Abstract

The calcium absorption and utilization in rats fed nanometer pearl powders diets was evaluated. The bone and serum calcium content, femur weight and length of rats fed the pearl powders diets was higher ($P < 0.05$) than those of rats fed the basic laboratory chow diet with low content of calcium. These parameters were significantly lower in rats fed nanometer pearl powders diets compared with those in rats fed micrometer pearl powders diets ($P < 0.05$). The results indicate that nanometer pearl powders diets may significantly increase calcium bioavailability and have important nutritional benefits based on the evaluation in the rats growth and development model.

Keywords: Nanometer pearl powder; Micrometer pearl powder; Calcium absorption; Calcium utilization

1. Introduction

The nacre (mother of pearl) layer of the giant oyster (Pinctada maxima) shell can initiate bone formation in vitro (Lopez et al., 1992) and in vivo (Atlan, Balmain, Berland, Vidal, & Lopez, 1997). Nacre is biocompatible and has osteogenic properties (Delattre, Catonne, Berland, Borzeix, & Lopez, 1997). Nacre implants in sheep (Delattre et al., 1997), rats (Atlan et al., 1999) and human for alveolar bone defects (Atlan et al., 1997) caused differentiation of osteoblasts leading to the formation of mature, functional bone (Sriamornsak, Sungthongjeen, & Puttipipatkhachorn, 2007). Nacre also initiates mineralization by human osteoblasts in vitro (Liao, Brandsten, Lundmark, & Li, 1997). Lopez et al. (1992) have suggested that nacre acts on osteogenesis via its organic matrix, which contains diffusible, water-soluble factors (Westbroek & Marin, 1998).

A natural pearl is formed by deposits of nacre around an irritant which accidentally lodges within the body of an oyster (Huang, Yu, & Xiao, 2006; Silve et al., 1992). A number of studies have indicated that pearl is an excellent source of calcium that is beneficial to the body. It contains over 25 organic salts and 10 amino acids, providing a rich source of organic calcium, selenium, zinc, and other trace metal elements. As the generation of people over 60 grows, there has been an enormous increase in the amount of osteoporosis, joint pain, and arthritis and a general decline in the quality of health (Atlan et al., 1997). Studies show that many falls experienced by the elderly are actually caused by a hip or knee spontaneously fracturing just before the fall occurs (Sriamornsak et al., 2007). Nanometer pearl powder (average diameter of 40–80 nm) is derived by thoroughly grinding natural pearls through a patented cutting-edge technology that makes the ingredients more bioavailable. Because the nanometer pearl powder is easily absorbed

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into the bloodstream, it replenishes the calcium deficit within a short period of time, as well as supplies some trace metal elements and thereby improve the immune system.

This study reports investigations on the effects of nanometer pearl powder on calcium absorption and utilization in rats with the aim to provide a scientific theory for future pharmacological application of nanometer pearl powder.

2. Materials and methods

2.1. Materials

Nanometer and micrometer pearl powders were kindly provided by the ZheJiang ChangShengNiao Medicine Co., Ltd. (Hangzhou, China). The calcium contents (35.0% and 34.6%) in both pearl powder loads were just taken from the chemical analysis datasheet from the provider. Other chemicals and reagents were analytical grade.

2.2. Animal and diets

One hundred ten, 21 days, SD rats weighing about 70 g, were obtained from the Laboratory Animal Center of Second Military Medical University (Shanghai, China). Animals were kept in an environmentally controlled breeding room (temperature: 20 ± 2 °C, humidity: $60 \pm 5\%$, 12 h dark/light cycle). They were fed basic laboratory chow diet with low level of calcium (0.1%) and allowed to free access to tap water for 4 days before the experiments. Experiments were conducted in accordance with the declaration of Helsinki and/or with the Guide for the Care and Use of Laboratory Animals as adopted and promulgated by the China National Institutes of Health. One kilogram basic laboratory chow diet contained 320 g corn, 300 g wheat, 150 g soybean meal, 200 g vegetable protein powder, 10 g salt and 20 g soybean salad oil.

$$\text{Retention rate of calcium in femurs } (\%) = \frac{\text{calcium content in femurs of experimental rats} - \text{one in femurs of control rats}}{\text{total calcium intake}} \times 100$$

$$\text{Total calcium intake} = \text{total feedstuff} \times \text{calcium content in feedstuff}$$

$$\text{Absorption rate of calcium } (\%) = \frac{\text{total calcium intake} - \text{calcium content in feces}}{\text{total calcium intake}} \times 100$$

$$\text{Retention rate of calcium } (\%) = \frac{\text{total calcium intake} - \text{calcium content in feces} - \text{calcium content in urine}}{\text{total calcium intake} - \text{calcium content in feces}} \times 100$$

2.3. Experimental protocol

Animals were randomly divided into six groups: I, II, III, IV, V and VI. Group VI consisted of 10 animals. Each of other groups consisted of 20 animals. Rats in group I were fed basic laboratory chow diet plus 5% micrometer pearl powder for 4 weeks; rats in group II were fed basic laboratory chow diet plus 10% micrometer pearl powder for 4 weeks; rats in group III were fed basic laboratory chow diet plus 5% nanometer pearl powder for 4 weeks; rats in group IV were fed basic laboratory chow diet plus 10% nanometer pearl powder for 4 weeks. Rats in group V were fed basic laboratory chow diet with low content of calcium for 4 weeks; 10 rats in group VI as experimental control were killed before experiment for analysis of femurs weight and length, calcium and phosphorus contents in femurs and serum.

Body weight of rats in groups I–V was monitored periodically (once per week). Three days before concluding the 50-day experiment, calcium content in feces and urine were measured. At the 28th day, rats were sacrificed by cervical dislocation and blood was collected, centrifuged at 1000*g*, 4 °C for 10 min immediately, and then used to assay serum calcium, and phosphorus contents. At the same time, the rats' femur was dissected and cleaned of soft tissue for later analysis of the bone calcium and phosphorus contents of the complete femurs.

2.4. Analysis

2.4.1. Calcium content

Calcium levels in femurs, feces, urine and feedstuff were measured by atomic absorption spectrophotometry (WYX400, ShengYang Analytical instrument Co., Ltd. (Shengyan, China) according to the methodology described by Stewart, Thompson, Furness, and Harrison (1994). Calcium concentrations were presented as $\mu g\ g^{-1}$ (ppm) of tissue on a dry weight basis. Analytical limits of detection were determined as 0.01 $\mu g\ g^{-1}$ dry weight.

Retention rate of calcium and total calcium intake can be calculated according to the method described by Alam, Kabir, Amin, and McNeill (2005). Absorption rate of calcium can be calculated according to the method described by Cui, Yong, Sun, Cao, and Tang (2005).

2.4.2. Femurs weight and length

Femoral length were measured with a caliper made in ShangHai Measuring & Cutting Tool Works (Shanghai, China) and bones were weighed on a precision balance (WP120-1) made in Shanghai Balance Instruments Works (Shanghai, China).