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Original Article

Effects of Korean Red Pepper on Lipid Metabolism in the Rats

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Effects of Korean red pepper on lipid metabolism were investigated using the rats. The red pepper was orally administrated as a part of diet. Daily intake of the red pepper decreased plasma triglyceride and deposit fat. The red pepper taken as a diet influences lipid metabolism and may have preventive effects on lifestyle-related disease.

Key Words: Pepper, Lipid Metabolism, Diet, Rat

Introduction

Pepper (*Capsicum annuum*) is a native plant in Central or South America, the fruit and seeds of which are used for food and spices. Pepper tastes hot due to the functional molecules such as capsaicin and dihydrocapsaicin that they contain. They are members of the capsaicinoids and have physiological functions in humans such as activation of fat metabolism, promotion of appetite, heat generation, and perspiration. These physiological functions of capsaicinoids are intermediated by increased secretion of catecholamines [1, 2]. The pepper has a potential to prevent lifestyle related disease by affecting fat metabolism as a functional food. However, it is difficult to intake a large quantity of pepper because of its pungency. Korean red pepper contains less capsaicin and dihydrocapsaicin, and much more capsaicin glycoside and capsiate than Japanese the red Takanotsume pepper. So, Korean red pepper is less pungent, and it is possible to ingest larger quantities as a vegetable. In this study we investigated the effect of Korean red pepper on fat metabolism through oral intake as a part of diet.

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Materials and Methods

Male Wistar rats 4 weeks old (Charles River Laboratories Japan, Inc.) were used. They were housed individually in cages on a standard 12h light/12h dark cycle at 24±2℃, humidity 60±5%, with food and water available ad libitum. All animal use procedures were in strict accordance with the Act on Welfare and Management of Animals in Japan.

When the rats grew up to 250g, they were divided into four groups: a control group receiving a standard diet (Oriental Yeast CO., LTD, MF), group R receiving a standard diet and 10% red pepper, group SR receiving a standard diet, 30% white sugar and 10% red pepper and group S receiving 30% white sugar. All groups were fed ad libitum for 7 to 8 weeks. Constituent parts of the diets are shown in Table 1. Dried Red pepper was produced in Korea and purchased from the National Agricultural Cooperative Federation, Imsil County, Korea. The red pepper is the Shinjokwang species, which contains 0.1 to 0.5% capsaicin glycoside and approximately 1.3% capsaicin. Compared with the Japanese pepper species Takanotsume, which

Table 1 Constituents of the diets/100 g

	Energy (kcal)	Water (g)	Protein (g)	Fat (g)	Carbohydrate (g)	Ash (g)	Dietary fiber (g)
Control	66.6	1.4	4.4	1	10.1	10.1	0.5
10% red pepper	67.7	1.3	4.2	1.1	10.3	10.3	0.5
30% sugar	67.9	1	3.1	0.7	12.6	12.6	0.4
10% red pepper and 30% sugar	69.0	0.9	2.9	0.8	12.8	12.8	0.3

contains approximately 4% capsaicin, the Korean red pepper is less piquant and pungent. The red pepper added to the diets was ground into powder and filtrated through a 500 μm mesh. The body weight, weight of food intake and weight of stool were measured. Some stool was used to detect excreted cholesterol. Blood was collected from the tail vain under ether anesthesia between 14:00 and 15:00, and the plasma was separated. Eight weeks after the feed, the rats were killed under deep anesthesia. The visceral adipose tissue around the testicles and posterior abdominal wall was removed and the weight was measured, and the small and large intestines were removed and weighed. The liver was also removed and weighed, and a sample removed for histological analysis.

The plasma was analyzed by Dry-Chem (FUJIFILM Medical Co., Ltd.). Triglyceride, triglyceride associated lipoproteins namely total cholesterol (TC) and HDL-cholesterol were measured. Arteriosclerotic index (AI) was calculated. Non HDL-cholesterol was calculated by subtraction of the HDL-cholesterol value from the TC value.

The cholesterol in the stool was measured using the Zak-Henly method, after extraction by mixing it with chloroform-methanol (v/v 2:1).

The results are expressed as the mean $\pm$ S.E. Statistical significance was evaluated by analysis of variance, followed by Student's t-test. Values of $p < 0.05$ were regarded as statistically significant.

Results

Growth rate was assessed by the increase in body weight in each group. Growth rate did not change and the rats showed a similar growth rate regardless of the diets (Fig. 1). Statistical significant differences were not observed in the daily intake of the diet among the groups, but group SR and group R showed an increased tendency in diet uptake (Fig. 2).

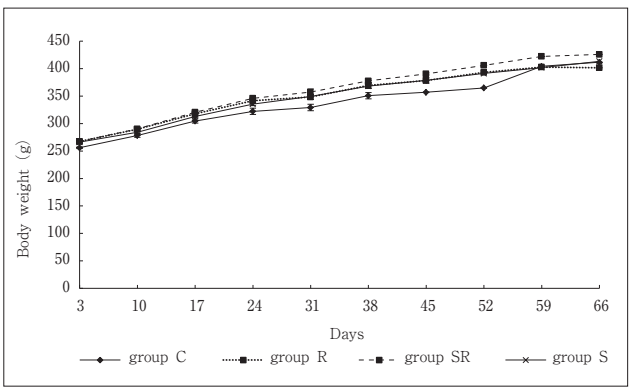

Fig. 1 Increase in the body weight of the rats by group

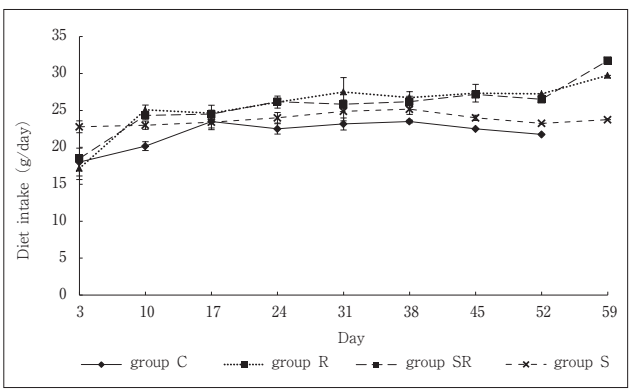

Fig. 2 Daily diet intake of the rats by group

Concerning the weight of the visceral adipose tissue, group R showed significantly decreased weight compared to the control (Fig. 3). In addition, group R showed significantly decreased weight of the intestines compared to the control group.

No difference was observed in plasma concentration of triglyceride among the groups (Fig. 4). The concentration of total cholesterol

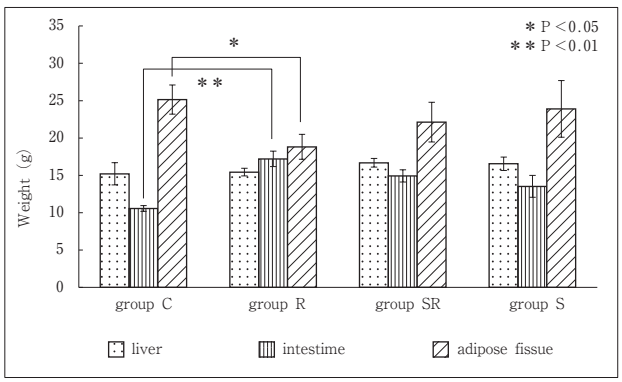

Fig. 3 Tissue weight of the rats by group

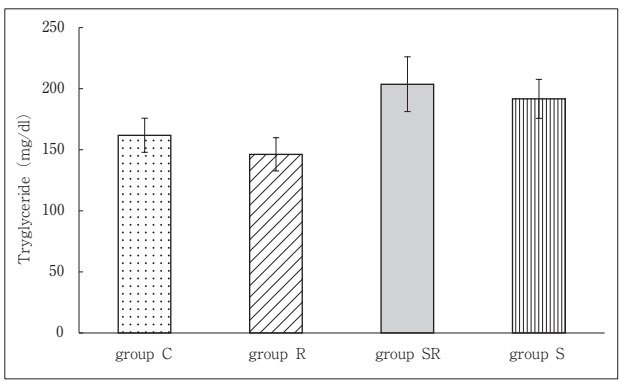

Fig. 4 Plasma triglyceride concentration of the rats by group

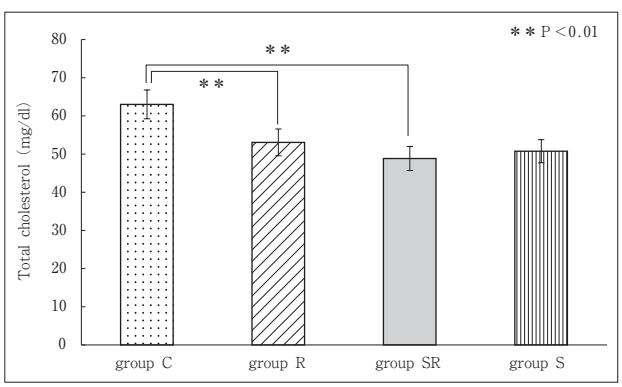

Fig. 5 Total plasma cholesterol concentration of the rats by group

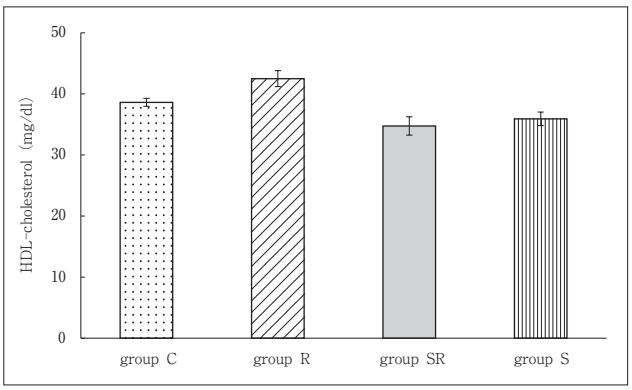

Fig. 6 Plasma HDL-cholesterol of the rats by group

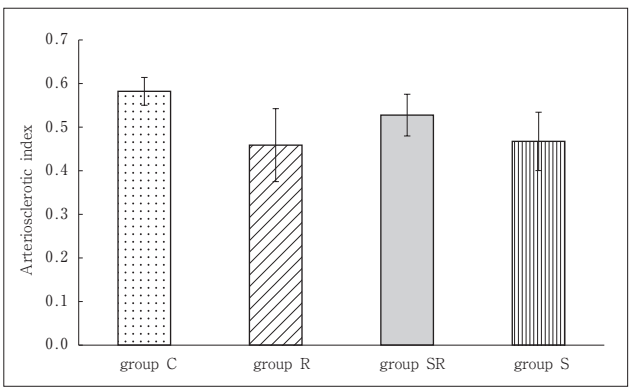

Fig. 7 Arteriosclerotic index of the rats by group

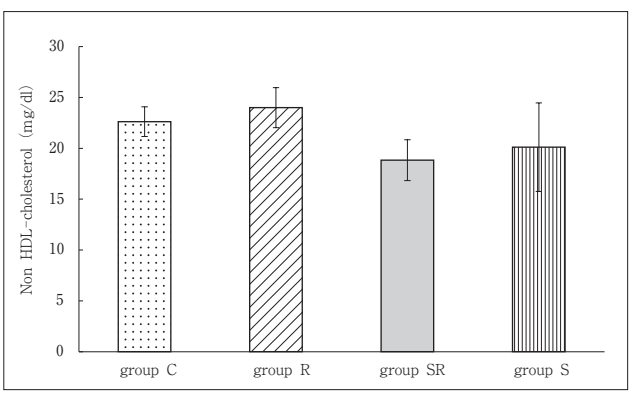

Fig. 8 Non HDL-cholesterol value of the rats by group

was significantly lower in the groups R and SR compared to the control group (Fig. 5). However, the concentration of HDL-cholesterol did not significantly change among the groups (Fig. 6). Furthermore, AI did not change among the groups (Fig. 7). The non HDL-cholesterol value was significantly lower in group R compared to the control group (Fig. 8).

Group R showed significantly increased weight of the stool compared to the control group, and group SR also showed significantly increased weight of

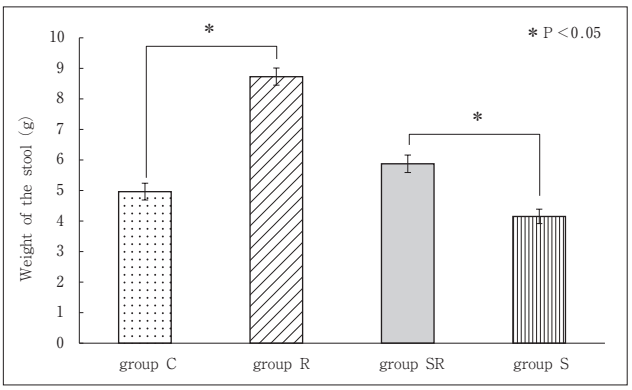

Fig. 9 Weight of the stool of the rats by group

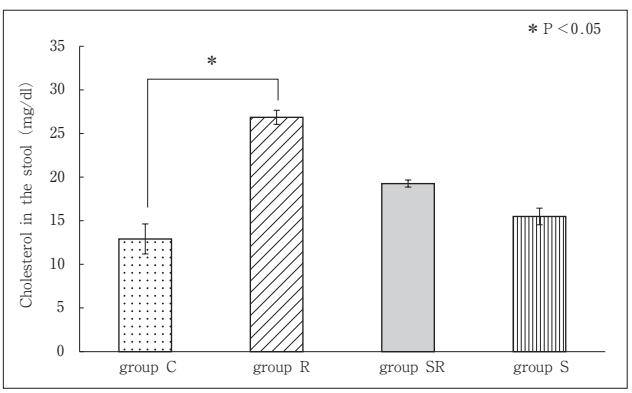

Fig. 10 Excreted cholesterol in the stool of the rats by group

the stool compared to group S (Fig. 9). Excreted cholesterol in the stool increased in group R compared to the control group (Fig. 10).

Discussion

The results of this study clearly show that orally taken red pepper reduced plasma TC and deposit fat, but has no influence on plasma triglyceride. Red pepper therefore influences fat metabolism, especially lipoprotein and adiposity. Few studies have investigated the effects of orally administered red pepper on fat metabolism. It is the pungent components or ingredients of the red pepper that probably influence fat metabolism. One of the molecules is capsaicin, and the effects of capsaicin on triglyceride or cholesterol have been investigated. Capsaicin has been shown to lower plasma triglycerides and triglycerides associated lipoproteins [3, 4]. In agreement with these previous research, the results of this study showed a similar influence on fat metabolism. The red pepper administered in this study contains less capsaicin but much more capsaicin glycoside and capsiate, so it is conceivable that capsaicin glycoside and capsiate exert the same effect on fat metabolism as capsaicin. The red pepper contains several kinds of capsaicinoids, so it is possible that a synergistic effect has been observed in this experiment. A recent study has revealed that capciate and capsaicin bind to the same receptor but capcitate did not induce nociception [5]. The other capsaicinoides contained in the red pepper may bind to the receptor and exert effects. Further analysis of the capsaicinoides and verification of the effect are necessary to clarify the nutrient function of the red pepper.

The two groups of rats fed red pepper (group R and group SR) showed an increased tendency for food intake. This result supports the notion that red pepper has an appetite promotion effect [6]. Group R tended to take in much more food but the body weight did not increase by much, and showed decreased visceral adipose weight. This is probably a result of enhanced energy expenditure due to the red pepper and consequent inhibition to reserve fat. Capsaicin induced reduction of adipose tissue has been reported, and different doses of capsaicin affect the volume of food intake and energy expenditure [7]. Group SR tended to increase body weight, appetite promotion effect and additional calorie intake through sugar, resulting in increased deposits of energy in adipose tissue. In the SR group the energy intake was enhanced much more than energy expenditure due to the red pepper.

The effects of red pepper on physiological function have been investigated previously. Capsaicin activates the sympathetic nervous system and increases catecholamine secretion from the adrenal gland. The secreted catecholamines bind with the β-adrenergic receptors and exert the effects [8]. So, the effect or influence of red pepper must be intermediated by hormones and the autonomic nervous system. Another recent study has also revealed that capsaicin, capsiate and an analogue of capsaicin bind to capsaicin-binding transient potential vanilloid 1 (TRPV1) receptors. However, their physiological effects are different [5]. TRPV1 receptors are found

mainly in the nociceptive neurons of the peripheral nervous system, but they have also been described in many other tissues, including the central nervous system [9, 10]. Capsaicin-like substances also gate TRPV1 receptors [11]. TRPV1 receptors in the hypothalamus probably influence appetite generation, and the capsaicinoids in the red pepper presumably exerts appetite promotion through the receptors.

Capsaicin-induced reduction of plasma triglyceride and cholesterol have also been reported [2, 3, 8]. Capsaicin activates lipase and decreases plasma cholesterol [12]. However, the results of this study did not show decreased plasma triglyceride due to red pepper ingestion. A much higher intake of red pepper may result in agreement with the results of previous reports. Capsaicin lowered the activity of HMG-CoA reductase, and enhanced the activity of cholesterol 7α-hydroxylase[13]. In addition, capsaiciniods inhibit cholesterol absorption, reduce resorption of bile acid and effectively lower plasma cholesterol level [14]. The results of this study showed increased cholesterol excretion in the rats fed red peppers, indicating the decreased absorption of cholesterol or resorption of bile acids by red pepper. Recent reports have revealed that capsaicin affects adipokine levels and glucose metabolism through insulin sensitivity [15, 16]. These results suggest that capcinoids have similar effects on metabolism as capsaicin. A new method has been developed to convert capsaicin to capciate [17]. Less pungent capsaicinoids including capciate can be taken in much larger quantities in humans with the potential to improve fat and glucose metabolism. Korean red pepper, taken in larger quantities as a vegetable, may reduce or prevent lifestyle-related disease.

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