Available online at www.sciencedirect.com

ScienceDirect

www.nrjournal.com

Corn gluten hydrolysate and capsaicin have complimentary actions on body weight reduction and lipid-related genes in diet-induced obese rats☆

Joo-Mi Mun[1], *Hyang Mok Ok*[1], *Oran Kwon*[*]

Department of Nutritional Science and Food Management, Ewha Womans University, 52 Ewhayeodae-gil, Seodaemun-gu, Seoul, 120-750, Republic of Korea

ARTICLE INFO

Article history:
Received 17 October 2013
Revised 11 February 2014
Accepted 15 April 2014

Keywords:
Corn gluten hydrolysate
Capsaicin
Rat
Obesity
Liver
High-fat diet

ABSTRACT

The aim of this study was to test the hypothesis that a combination of corn gluten hydrolysate (CGH) and capsaicin may have an additive or synergistic effect on body weight reduction. For 13 weeks, male Sprague-Dawley rats were provided a diet to induce obesity. Afterward, the rats were randomly divided into 5 dietary groups: the normal control (n = 5), the high-fat control (n = 8), the high-fat diet (HFD) containing 35% CGH (n = 7), the HFD containing 0.02% capsaicin (HF-P) (n = 8), and the HFD containing both CGH and capsaicin (HF-CP) (n = 7) for an additional 4 weeks. Administration of CGH plus capsaicin, along with a HFD, led to significant decreases in body weight, fat mass, lipids in the liver, and plasma leptin as well as increases in plasma adiponectin. The pattern of gene expression was different in each target organ. In the liver, up-regulation of peroxisome proliferator-activated receptor α, carnitine palmitoyltransferase 1α, and acyl-coenzyme A oxidase was found in the HF-CP group. In contrast, down-regulation of peroxisome proliferator-activated receptor γ was found in both the HFD containing 35% CGH and HF-CP groups. In skeletal muscle, up-regulation of insulin receptor and uncoupling protein 3 was found in the HF-P group only, whereas up-regulation of the glucose transporter 4 gene was observed in both the HF-CP and HF-P groups. In adipose tissue, up-regulation of peroxisome proliferator-activated receptor γ and hormone-sensitive lipase was only found in the HF-CP group. In summary, this study suggests that CGH and capsaicin perform complementary actions on food intake, lipid metabolism, and insulin sensitivity by a coordinated control of energy metabolism in the liver, adipose tissue, and skeletal muscle, thus exerting an additive effect on body weight reduction.

Abbreviations: ACO, acyl-coenzyme A oxidase; ANOVA, analysis of variance; CGH, corn gluten hydrolysate; CPT-1α, carnitine palmitoyltransferase 1α; DIO, diet-induced obesity; GLUT4, glucose transporter 4; HFD, high-fat diet; HOMA-IR, homeostasis model assessment–insulin resistance; HSL, hormone-sensitive lipase; INSR, insulin receptor; mRNA, messenger RNA; PPARα, peroxisome proliferator-activated receptor α; PPARγ, peroxisome proliferator-activated receptor γ; RT-PCR, real-time polymerase chain reaction; UCP3, uncoupling protein 3; WAT, white adipose tissue.

☆ This study was supported by the Ministry of Science, ICT, and Future Planning (Gwacheon, Korea) through the National Research Foundation (Bio-synergy Research Project NRF2013M3A9C4078153), the Ministry of Knowledge and Economy (Sejong, Korea, National Platform Technology Project B10033818), and the Ministry of Education, Science and Technology (Sejong, Korea, BK21PLUS 22A20130012143). These extramural funding sources had no influence in the design, collection, analysis, and interpretation of the data; the writing of this report; or the decision to submit this manuscript for publication.

* *Corresponding author*. Tel./fax: +82 2 3277 6860.
E-mail address: orank@ewha.ac.kr (O. Kwon).

[1] First authors J. Moon and H.M. Ok contributed equally to this article.

http://dx.doi.org/10.1016/j.nutres.2014.04.009

1. Introduction

Obesity is a complex metabolic disorder that is thought to result from an imbalance of energy intake and energy expenditure that leads to an excess accumulation of fat in adipose tissues and organs. Obesity is associated with the genesis or development of various diseases, including coronary heart disease, hypertension, type 2 diabetes mellitus, cancer, respiratory complications, and osteoarthritis [1]. Fat is the primary energy storage form in mammals. Adipose tissue, skeletal muscle, and liver are important tissues capable of hydrolyzing stores of triacylglycerol [2]. It is reported that diets high in fat contribute to obesity in both rodent and human models [3,4]. Diet-induced obesity (DIO) models are widely used to find effective functional foods or components for preventing and/or reducing obesity.

Corn is an abundant source of branched chain amino acids, such as leucine [5], which is well known to stimulate muscle protein synthesis and decrease body weight by stimulating hypothalamic mammalian target of rapamycin signaling [6]. We previously demonstrated that corn gluten hydrolysate (CGH) has antiobesity effects in DIO model rats [7]. In the following study, we focused on the mechanism of CGH in adipose tissue, which demonstrated a significant decrease in the plasma leptin [8]. Furthermore, capsaicin (8-methyl-*N*-vanillyl-*trans*-6-nonenamide), a major and pungent ingredient in red pepper, is widely used as a spice. Several lines of evidence suggest that it retards body weight gain and body fat in rats by increasing thermogenesis in white adipose tissue (WAT) through enhancement of catecholamine secretion from the adrenal medulla [9,10], stimulating lipid mobilization from adipose tissue, lowering serum triglyceride (TG) concentration [11], and reducing energy intake by increasing sympathetic nervous system activity rather than taste aversion [10]. The addition of red pepper (10 mg/kg body weight) to high-fat meals significantly decreased WAT weight and increased fatty acid oxidation in rodents [12].

We hypothesized that capsaicin could exert a complementary action to the antiobesity effect of CGH in high-fat–fed obese rats. The specific objectives of the study were (1) compare biochemical and molecular parameters of CGH and capsaicin, alone and in combination, of on rat body weight reduction, insulin sensitivity, and lipid metabolism; and (2) assess interorgan signaling between the fat and insulin sensitivity in the liver, adipose tissue, and skeletal muscle in response to a combination of CGH and capsaicin. The focus is to understand the molecular physiologic actions involved in energy metabolism.

2. Methods and materials

2.1. Rats and diets

Forty-five male Sprague-Dawley rats (approximately 320-330 g) were obtained from G-Bio Co (Gwacheon, Korea), and a DIO model was established. The rats were housed in individual stainless steel cages, which were maintained at a temperature of 23°C ± 1°C with 12/12-hour light/dark cycles and 45% ± 5% humidity. They were provided free access to water and a chow diet for a week before the experiment. For this study, obesity was induced by feeding a modified AIN-93G diet for 13 weeks, with approximately 60% of the calories (soybean oil + lard) derived from fat (high-fat diet [HFD], n = 35). Another group of rats, used as the control, were fed a modified AIN-93G diet with approximately 18% of the calories from fat (soybean oil) (normal fat diet [NFD], n = 10). After 13 weeks, obesity induction was confirmed by the measurement of body weight and WAT weight from rats in the HFD (n = 5) and NFD groups. The remaining rats from the HFD group were randomly divided into 4 groups (n = 7-8 for each group) for an additional 4 weeks: one group was fed an HFD only (high-fat control [HF]); 2 groups were fed an HFD containing either 35% CGH (HF-C) or 0.02% capsaicin (HF-P); and the last group was fed an HFD containing 35% CGH + 0.02% capsaicin (HF-CP). The remaining rats from the NFD group continued to receive NFD (normal control [NF]). After reassignment of the groups, the experiment continued for an additional 4 weeks, with the rats having free access to the diet and water during this time. The experimental protocol was reviewed and approved by the Institutional Animal Care and Use Committee of Ewha Woman's University.

The ingredient composition of the experimental diets is shown in Table 1. To be consistent with our previous study [7,8], we used CGH as the sole source of protein (35% of diet) by replacing the casein in the diet. The dose of capsaicin (0.02% of diet) was determined based on the results of the 2008-2009 Korea National Health and Nutrition Examination Survey, which determined the average intake level among the Korean population. This level of concentration is similar to other animal studies that demonstrate the beneficial effect of capsaicin [11,13].

Table 1 – Ingredient composition of the experimental diets [a]

Ingredients	NF (n = 5)	HF (n = 8)	HF-C (n = 7)	HF-P (n = 8)	HF-CP (n = 7)
g/kg					
Corn starch	397.49	0	0	0	0
Dextrin	132	149.76	63	151	60.8
Sucrose	100	102.11	102.11	101.11	102.11
Casein	200	272.29	0	272.29	0
CGH	0	0	353.33	0	353.33
Capsaicin	0	0	0	0.2	0.2
Soybean oil	70	95.3	101	94.9	103
Lard	0	243	243.7	243.7	243.7
Fiber	50	68.07	68.07	68.07	68.07
AIN-93 minerals	35	47.65	47.65	47.65	47.65
AIN-93 vitamins	10	13.61	13.61	13.61	13.61
L-Cystine	3	4.08	4.08	4.08	4.08
Choline bitartrate	2.5	3.4	3.4	3.4	3.4
Tert-butylhydroquinone	0.01	0.02	0.02	0.02	0.02
Protein (%, wt/wt)	17.8	24.2	24.6	24.2	24.6
Carbohydrate (%, wt/wt)	59.8	26.7	27.1	26.7	27.2
Fat (%, wt/wt)	7.1	33.9	34.5	33.9	34.5
Energy (kJ/g diet)	15.65	21.30	21.63	21.30	21.67

[a] Diets were prepared according to the AIN-93G diet with slight modifications.