Lipid Nutrition and Healthy Aging

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Summary Bioactive food factors are considered to be critical for health promotion and play an important role in the prevention of lifestyle-related diseases. Metabolic syndrome, a typical common disease, is a cluster of metabolic disorders, such as abdominal obesity, the combination of hypertriglyceridemia and lower level of HDL, hypertension and diabetes mellitus, that contribute to increased cardiovascular morbidity and mortality. In addition, the incidence of metabolic syndrome and non-alcoholic fatty liver disease (NAFLD) is closely linked with the increase in inflammation and the disorders of lipid metabolism. The pathogenesis of metabolic syndrome and related diseases is complicated. However, food factors have been recognized as contributing factors in the development and prevention of these diseases. Provocative evidence profoundly supports the preventive role of dietary bioactive lipids, polyphenols and other food ingredients. Recent studies suggest the central role of nuclear transcription factors in the pathogenesis of obesity and NAFLD. The goal of the present symposium is to enhance our understanding of cellular and molecular effects of bioactive food factors against obesity related pathogenesis.

Key Words metabolic syndrome, lipids, C/EBPβ, carotenoid, food factor

It is well established that omega-3 (ω3) PUFAs are key regulators of neural development and function, and in preventing various health condition with inflammatory or immune components. Most health benefiting studies were performed using fish oil, which is a mixture of various fatty acids, and the positive effects were often attributed to EPA (20:5 w3) and DHA (22:6 w3). However, the physiological effects of other w3 PUFA such as DPA (22:5 w3), an elongated species of EPA, and THA (24:6 w3) which contain in seals and zebra fish, are scarcely understood. It has also been demonstrated that dietary phospholipids and other so-called structure lipids have beneficial effects on health when compared with dietary triacylglycerol (TAG). Professor K. Nagao’s group in Saga University, Japan, studied the physiological functions and molecular actions of functional lipids, especially omega3-PUFA-containing lipids and phospholipids, in the development of metabolic syndrome using obese animal models. Their studies revealed that feeding of omega3-PUFA lipids, such as EPA-TG, DPA-TG, DHA-TG, THA-TG, could alleviate hepatic lipid accumulation through the suppression of lipogenic gene expression in the liver. Additionally, dietary ω3-PUFA-containing lipids increased levels of serum adiponectin, an anti-inflammatory protein, in obese animal models. They also found that dietary ω3-containing phospholipid and EPA-polar lipids in salmon roe and seaweed, and soybean phosphatidylinositol could prevent fatty liver through the enhancement of PPAR-delta and by reducing SREBP1c. The results from their study indicate that dietary functional lipids would be useful to prevent or alleviate metabolic syndrome in obese animals. In particular, the function of these bioactive lipids as an adiponectin inducer deserves attention with respect to alleviation of metabolic syndrome by dietary manipulation.

Professor S. M. Rahman, Texas Tech University, USA, will review the pathogenesis of obesity. Obesity is a worldwide epidemic and is associated with nonalcoholic fatty liver disease (NAFLD), inflammation and the development of atherosclerosis. In his group’s studies, they have focused on the role of a nuclear transcription factor, CCAAT/enhancer binding protein beta (C/EBPβ), on the development of obesity-related metabolic disorders including NAFLD, inflammation and atherosclerosis. Using global C/EBPβ-deficient mice, they have shown that loss of C/EBPβ prevents high-fat diet- and LXR agonist (T0901317)-mediated induction of hepatic TG accumulation and lipogenesis. In addition, loss of C/EBPβ induces browning of white adipose tissue and increases mitochondrial biogenesis. Using a bone marrow transplantation technique, they have further shown that C/EBPβ in bone marrow cells is the key regulator of high-fat diet-induced adipose tissue inflammation and insulin resistance. They further have shown that ApoE−/− mice (an animal model of atherosclerosis) lacking C/EBPβ in bone marrow cells prevent high fat-high cholesterol (HF/HC) diet-mediated hypercholesterolemia, systemic inflammation and lesion formation in the aorta. The results from their studies suggest that C/EBPβ plays crucial roles in the regulation of NAFLD, adipose tissue inflammation and atherosclerosis development. Thus, inactivation of C/EBPβ may hold promise to prevent obesity-associated pathogenesis.

Higher LDL-cholesterol and lower HDL-cholesterol levels are risk factors for the development of atherosclerosis. Diet, apart from activity and genetics, is a very
important factor that influences cholesterol level. Professor M-T Chiang, National Taiwan Ocean University, Taiwan, will talk about the relationship between dietary fatty acids and plasma cholesterol levels. It is known that different protein sources may play a role in regulation of eicosapentaenoic acid (EPA) effects when cholesterol is supplemented. In his group’s study, they investigated the comparative effects of fish oil in soy protein isolate (SPI) and casein diet on plasma lipids, lipoprotein cholesterol, fatty acid composition and lipid peroxidation in rats fed a diet without cholesterol supplementation. Sprague Dawley rats were fed one of the following diets: (1) casein diet, (2) casein + fish oil diet, (3) SPI diet, (4) SPI + fish oil diet, or (5) SPI + fish oil + methionine diet for 8 wk. They found that fish oil and SPI decreased synergistically plasma TC, HDL-C, LDL-C, and VLDL-C levels. In addition, the SPI + fish oil + methionine group had lower plasma TG when compared with other groups. However, fish oil supplementation increased hepatic TBAR values in both the casein and SPI groups. Methionine treatment ameliorated the increased hepatic TBAR values. The proportion of 18:1 in hepatic phospholipids was decreased after fish oil supplementation, suggesting the suppression of stearoyl-CoA desaturase. Fish oil significantly decreased hepatic glucose-6-phosphate dehydrogenase activity, but no significant difference in hepatic malic enzyme was observed. They concluded that supplementation to cholesterol and fish oil may affect other factors on the bioavailability of carotenoids.

Professor Chandrika Udumalagala Gamage, University of Sri Jayewarenepura, Sri Lanka, will give a talk about the influence of dietary lipids on bioaccessibility and bioavailability of carotenoids. Carotenoids are lipid-soluble pigments found in many fruits and vegetables. Apart from their well-known vitamin A activity, they process antioxidant, anticancer, immune enhancement and anti-obesity activities related to prevention of degenerative diseases. The intestinal absorption of carotenoids occurs primarily in the small intestine, in several steps including: (1) release from the food matrix; (2) incorporation into bile-salt mixed micelles; (3) uptake by intestinal mucosal cells; and (4) incorporation into chylomicrons. Absorption of dietary carotenoids is affected by several factors. Dietary lipid is a positive promoter of carotenoid absorption in vivo. The objective of this lecture is to discuss current knowledge of the impact of dietary lipids on carotenoid bioaccessibility and bioavailability in humans. There are reports that consumption of cooked vegetables containing oil resulted in a significant increase in serum retinol concentrations in humans. In support of these findings, the research group carried out in vitro studies and found that that in traditional methods of cooking in Sri Lanka where coconut milk is added to the vegetables, the proportion of in vitro availability of all-trans-β-carotene is much higher than in the same vegetables cooked with water. It is also recognized that co-consumption of lipid in the form of triacylglycerol is one of the most effective stimulators of carotenoid absorption in vivo. MUFA-rich lipids promote greater carotenoid absorption than PUFArich lipids, especially for the more polar carotenoids. Research has shown that the impact of SFA on carotenoid absorption is complex. It is also suggested that beta-carotene may have lower solubility in micelles composed of MCT than of LCT, leading to lower intestinal absorption. Future in vitro and in vivo investigations should be focused on the effect not only of dietary lipids but also of the interactions between dietary lipids and other factors on the bioavailability of carotenoids.

REFERENCES

6) Huang YS, Yanagita T, Knapp H, eds. 2006. Dietary Fats and Risk of Chronic Disease, AOCS Press, USA.