浙江省第三届青年学术论坛

THIRD ZHEJIANG YOUTH ACADEMIC FORUM

WHO/FAO 高层专家论坛

“食品安全性、食品科技和食品产业发展国际学术研讨会”论文集

食品安全、营养与发展

EVOLUTION OF FOOD SAFETY AND NUTRITION

主编 励建荣 李 铎

中国农业科学技术出版社

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主办

浙江省科学技术协会

WHO/FAO 食品营养专家组会议

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图书在版编目(CIP)数据

食品安全、营养与发展：国际学术研讨会论文集/励建荣，李铎主编.-北京：中国农业科学技术出版社，2002.10
ISBN 7-80167-479-0

I.食... II.①励...②李... III.食品工业-国际学术会议-文集 IV.TS2-53

中国版本图书馆CIP数据核字（2002）第080070号

责任编辑	刘晓松　韩扬云
责任校对	马丽萍　陈　良
技术设计	韩扬云　潘孝忠
出版发行	中国农业科学技术出版社　邮编：100081 电话：(010) 68919711　传真：68919698
经　　销	新华书店北京发行所
印　　刷	杭州富春印务有限公司
开　　本	880mm×1230mm 1/16 印张：25
印　　数	1-600册　字数：700 千字
版　　次	2002年10月第1版　2002年10月第1次印刷
定　　价	80.00元

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浙江省第三届青年学术论坛

——食品安全性与食品科技、产业发展国际学术研讨会

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浙江省第三届青年学术论坛论文集
——食品安全、营养与发展
编 辑 委 员 会

前　言

“浙江省青年学术论坛”是浙江省科学技术协会主办的高层次、大规模、综合性学术交流活动。她面向广大青年科技工作者，依托所属140多个省级自然科学学会（协会、研究会），旨在营造贯彻“双百”方针、倡导创新文化、宏扬科学精神、符合时代潮流的学术环境和学术气氛，推动浙江省新世纪人才工程建设、文化大省建设和科教兴省。

本届学术论坛已是第三届。“食品安全性、食品科技和食品产业发展国际学术研讨会”作为分论坛暨WHO/FAO高层专家论坛，是继2000年首届学术论坛——“21世纪食品与生物技术发展研讨会”后又一次与食品相关的高层学术会议。会议由浙江省科学技术协会、WHO/FAO食品营养专家组主办，中国食品科学技术学会、浙江省食品学会、杭州商学院、浙江省农学会、浙江省预防医学会、浙江省生物工程学会、浙江省环境科学学会、浙江省营养学会、浙江省畜产品技术协会、浙江省植物保护学会、浙江省土壤肥料学会等11家单位联合承办。会议得到了各界人士的关注。FAO（联合国粮农组织）食品质量、安全与营养中心主任、国际营养科学联盟主席Mark L Wahlqvist教授、FAO/WHO食品营养专家组成员Gayle S Savige博士、Naiyana Tikky Wattanapenpaiboon博士、Robert Premier博士、李铎（澳籍）博士等到会并作专题发言。会议还邀请了美国Auburn大学Peggy Hsieh教授和英国Cranfield大学Anwar Haque博士前来参会。本次会议共有来自世界和全国各地的专家、学者近200人参加。会议于2002年10月23—24日在杭州商学院举行。

本次会议多行业、多学科的参与，正体现了会议的主题——食品安全、营养问题所涉及面之广，与各学科关系之密切。食品安全与营养是食品科学永恒的主题，它与环境质量、种养技术、生物技术、加工技术、检测技术以及卫生管理、疾病预防等密切相关。同时，食品安全与营养又是一个超越国界的全球性问题，它的意义不仅在于卫生和健康，还在于对经济的影响，特别是一些发达国家将其充当贸易保护的技术壁垒后，对已加入WTO的中国影响巨大。

本次会议共收到代表提交的论文近100篇。内容涉及食品科学与营养、食品安全、食品技术与产业发展等。特别是食品营养与人类健康、农业与食品安全、现代生物技术与食品安全、食品检测等方面的相关内容，反映了目前国际、国内在食品安全、营养等方面的研究进展和发展趋势。经过论文集编委会的认真审核与筛选，选择其中87篇入编论文集——《食品安全、营养与发展》；并根据来稿的内容和性质，分别编入“食品科学与营养”、“食品安全”、“食品技术与产业”三个篇章。

限于时间和水平，在编撰中难免有遗漏和错误，敬请各位作者和读者原谅！

编　者

2002年9月于杭州

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食品科学与营养

Biosynthesis of 2-series Eicosanoids Influenced by Animal Fat Intake in Healthy Men

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Abstract In the present study we investigated the effect of dietary saturated fat (SFA) from animal sources on the urine excretion 11-dehydro thromboxane B_2 (TXB_2) and 6-keto prostaglandin F 1α (PGF 1α in 27 healthy aged 30 to 55 years free-living male subjects. Each volunteer was randomly assigned to one of the two diets (high fat (HF) and low fat (LF)) for a period of 4 weeks, after which each subject resumed his usual diet for 2 weeks as a 'wash-out period', before being assigned to the other diet for a further 4 weeks. Serum proportion of 20:4n-6 was 5% lower in the HF (6.2% of total fatty acid) than in the LF diet (6.5% of total fatty acid), which was associated with a significantly decreased ratio of the urinary excretion 11-dehydro TXB_2 to 6-keto PGF 1α ($p < 0.05$). However, there was no significant fall in the absolute urinary excretion of 11-dehydro TXB_2. Diet rich in SFA from animal sources may influence TXA_2 formation via effect on tissue proportion of 20:4n-6.

动物脂肪影响人体 2 - 系列二十烷类的生物合成

李 铎

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摘 要 在本课题中,我们对食物中动物饱和脂肪酸对尿液里 11-dehydro thromboxane B_2 (TXB_2) 和 6-keto prostaglandin F 1α (PGF 1α)在 27 位年龄在 30 至 55 之间健康男子的排泄进行了研究。我们将志愿者任意分成高脂肪和低脂肪饮食两组共四周,然后志愿者恢复他们的习惯饮食两周作为"洗脱期",再吃四周的另一种饮食。血清花生四烯酸的比例在高脂肪饮食中比在低脂肪饮食中低 5%,这与显著降低的尿液 11-dehydro TXB_2 与 6-keto PGF 1α 比率是相关联的。但是尿液排泄的 11-dehydro TXB_2 绝对值没有显著降低。饮食中动物源饱和脂肪酸可能通过影响组织花生四烯酸的含量而影响血栓烷胺的形成。

1 Introduction

Thrombus formation may be an integral part of the atherosclerosis and the acute event, which leads to a myocardial infarction or sudden cardiac death. The thrombi formation is initialed by platelet aggregation. The ratio of thromboxane A_2/prostacyclin I_2 (TXA_2/PGI_2) plays a critical role in platelet aggregation (Moncada and Vane 1979). TXA_2 and PGI_2 are biosynthe-

sized from arachidonic acid (AA) through the cyclooxygenase pathway in the platelet membrane and arterial endothelial cells, respectively (Hamberg et al. 1975, Moncada et al 1979). Any factors which affect the balance of TXA_2/PGI_2 in favour of PGI_2 should reduce the risk of thrombosis, whereas factors altering the balance in favour of TXA_2 should increase thrombosis tendency. Evidence from dietary intervention studies have found that the ratio of TXA_2/PGI_2 was decreased by marine omega-3 polyunsaturated fatty acid (n-3 PUFA) in humans (von Schacky et al 1985, Ferretti et al 1998) and in animals (Abeywardena et al 1991, Ikeda et al 1998), and by plant n-3 PUFA alpha-linolenic acid in both humans (Bjerve et al 1987) and animals (Budowski et al 1980, Lee et al 1988). A recent study by Kelly et al (2001) reported that diet enriched in 16:0 resulted in an increased ex vivo collegan and ADP induced whole blood platelet aggregation when compared with 18:0 enriched diet. However, there is no data on the relation between dietary saturated fat from animal sources and the biosynthesis of TXA_2 and PGI_2 in the literature. The aim of the present study was to investigate the effect of die tary saturated fat from animal sources on urine stable metabolites of TXA_2 and PGI_2, 11-dehydro thromboxane B_2 (TXB_2) and 6-keto prostaglandin F 1α (PGF 1α) (Campbell 1990).

2 Methods and Materials

Subjects and study design: The study protocol was approved by Deakin University Ethics Committee, and an informed written consent was obtained from each volunteer. Thirty-three healthy, free-living male omnivorous aged 30 to 55 years were recruited through newspaper advertisements. Exclusion criteria for this study were: individuals with symptoms or prior diagnosis of cardiovascular, renal disease, diabetes, or other chronic diseases, who are on long-term medications, athletes who train regularly for competitive sports and alcohol consumption exceeded 10 percent of daily energy intake.

Prior to commencement, participants were given detailed instructions on the diets to be consumed, and on how to accurately accomplish a weighed food record. Each subject was provided with a calibrated digital weighing scale (accurate to 1 gram), together with standard household measuring devices such as cups and spoons. Each volunteer was asked to complete a 4-day weighed diet record, including 2 weekend days, on their usual diets. The results of the initial weighed food record were used to calculate the daily energy allowance for each individual. The habitual diet and usual food choices of each individual were also considered in the planning of the diets to enhance compliance. The diets in this study were carefully calculated and planned by a dietitian.

A randomized crossover design was used to compare the effects of two diets. Each volunteer was randomly assigned to one of the two diets for a period of 4 weeks, after which each subject resumed his usual diet for 2 weeks as a 'wash-out period', before being assigned to the other diet for a further 4 weeks. The two diets were designed to provide similar amounts of energy, protein, dietary fiber, and alcohol, differing only in the amount of fat. The high fat (HF) diet was designed to provide 10% ~ 15% more energy from animal fat compared to the low fat (LF) diet. The HF diet provided approximately 42% ~ 45% of energy from fat (22% ~ 25% saturated fat) from full fat dairy products, and specially prepared biscuits containing lard. Butter, margarine, and the lard-containing biscuits were provided free to each subject. The LF diet provided approximately 22% ~ 25% of energy from fat (8% from saturated fat), and included low fat milk, cheese, yogurt, and monounsaturated margarine. The two diets were made isoenergetic by providing a greater amount of carbohydrate (55% ~ 60% of total daily energy) during the LF diet in the form of refined cereals, white bread, pasta, and sugar-containing beverages.

Both diets included 130 grams (raw weight) of very lean red meat each day, with a choice of beef or lamb. All meat consumed in the study was purchased from a single source (Top Cut Food Industries Pty., Ltd., Melbourne, Australia). The portion sizes of meat were pre-weighed and individually packed, and provided free of charge to each subject. Meals were prepared by the subjects and consumed at home. In addition to the di-

etary instructions, subjects were also asked to keep their physical activity pattern as similar as possible during the two diets. The subjects were contacted weekly during the study to monitor compliance and to provide dietary counseling. On the last week of each diet, subjects were instructed to accomplish a 7-day weighed diet record. All diet records were analyzed using FoodWorks version 1.2 (Xyris Software Pty. Ltd., Highgate Hill, Queensland, Australia), a dietary analysis software with nutrient composition data of Australian foods (Composition of food, National Food Authority, Australia, 1995).

The height and weight of each subject was measured at the commencement of the study and after each diet period, and the body mass index (BMI) was calculated. Venous blood samples were collected into plain vacutainer tubes for the collection of serum, prior to the study and on two occasions three days apart at the end of each diet. Blood samples were collected after an overnight fast between 07.00 h and 09.30 h. Blood samples were stored at-80℃ for later analysis.

Serum fatty acids: Serum lipids from 12 randomly selected subjects were extracted by chloroform: methanol (1:1, v/v) containing 10mg/L of butylated hydroxytoluene (Labco, VIC Australia), and 10 mg/L of C17:0 triacylglycerol (triheptadecanoin). Methyl esters of fatty acids of serum lipids were prepared by saponification using 0.68 mol/L KOH in methanol followed by transesterification with 14% BF3 in methanol. Methyl esters of fatty acids were separated by gas chromatography as described by Sinclair et al. (1987).

Urine concentrations of 11-dehydro thromboxane B_2 and 6-keto prostaglandin F 1α: Twenty-seven subjects collected their 24-hour urine on the last day of each of the diets. The samples were stored at-20℃ for later analysis. The concentrations of 11-dehydro TXB2 and 6-keto prostaglandin F 1α in the urine was determined by using an enzyme immunoassay (EIA) method with commercially available EIA kits (Cayman Chemical Company, MI, USA) as described elsewhere (Pradelles *et al*, 1985).

Statistical analyses: All data were performed using the Statistical Package for the Social Sciences version 8.0 (SPSS Inc. Chicago, IL, USA). The General Linear Model (GLM) was used to compare the results at the end of the two diet periods, taking carry-over effects into consideration (Fleiss, 1986). The values were reported as mean ± SD in all the results tables. P values were two-sides, and <0.05 was considered as significant.

3 Results

Thirty-three subjects enrolled in the study, mean age of 41.2 ± 7.8 years and mean BMI of 26.5 ± 3.0 kg/m^2 at baseline. However, only 27 subjects were included in the final results because six subjects did not collect urine at the end of both dietary periods. The mean daily intakes of total fat, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) expressed as gram and percentage of total energy, and cholesterol were significantly higher in the HF than in the LF dietary period ($p < 0.01$). Compared with HF, mean daily intakes of carbohydrate and the ratio of PUFA to SFA were significantly higher in the LF dietary period (Table 1).

Serum proportion (% of total fatty acid) of total SFA, total n-6 PUFA, 14:0, 18:0, 20:0 and 18:1 were significantly higher, and 18:3n-3, 22:5n-3, total n-3 and the ratio of n-3 to n-6 were significantly lower on the HF than on the LF dietary period ($p < 0.05$). Serum proportion of 20:4n-6 was higher on the LF (6.5% of total fatty acid) than on the LF diet (6.2% of total fatty acid) ($p = 0.06$) (Table 2). Serum concentrations of total and LDL cholesterol were significantly higher on the HF diet compared with on the LF diet. There was no significant difference in serum HDL cholesterol and triacylglycerol concentrations between two diets.

The concentrations of daily urine excretion of 11-dehydro thromboxane B_2 and 6-keto prostaglandin F 1α are reported in Figure 1 and 2. Mean daily urine excretion of 11-dehydro thromboxane B2 were 903 ± 65 ng/day and 1007 ± 63 ng/day, 6-keto prostaglandin F 1α were 377 ± 37 ng/day and 360 ± 32 ng/day for the HF and LF diet, respectively. Ratio of 11-dehydro TAB2 to 6-keto PGF 1α in urine was significantly lower in the HF (2.7 ± 0.2) than in the LF dietary period (3.1 ± 0.3) (Figure 2).

4 Discusion

Effect of n-3 and n-6 PUFA on thromboxane A_2 and prostacyclin I_2 has been well documented in both the human and animal studies. However, there is no data on the effects of the diet high in saturated fat from animal sources on the ratio of urine stable metabolites of TXA_2/PGI_2 in literature. We have measured fatty acid composition in serum as a marker of dietary individual fatty acid intake, since a comprehensive database on the individual fatty acid content of foods is not available in Australia. In the present study, high animal fat diet results in a decreased proportion of 20:4n-6 by 5% in serum ($p = 0.06$), which is associated with a 10% decreased 1-dehydro TXB_2 ($p = 0.09$) and 13% decreased ratio of urine excretion of 11-dehydro TXB_2 to 6-keto PGF 1α compared with the LF diet ($p = 0.03$).

TXA_2 and PGI2 are biosynthesized from arachidonic acid by the cyclooxygenase pathway. TXA_2 is formed in platelets and it is a potent cellular regulatory agent with strong platelet-aggregating activity (Hamberg et al. 1975), and it is also a potent vasoconstrictor (Bhagwat et al. 1985). TXA_2 can be broken down nonenzymatically ($t_{1/2}$ = 3 minutes) into the thromboxane B_2 (TXB_2), a stable metabolite (Gryglewski et al. 1988, Campbell 1990). PGI_2 is formed in vascular endothelial cells (Moncada et al. 1976). PGI_2 is released by endothelium and it only effects the local environment; it is a powerful vasodilator on the abluminal side of vessels and inhibits platelet aggregation on the luminal side (Vane et al. 1990). PGI_2 is hydrolyzed nonenzymatically ($t_{1/2}$ = 3 minutes) to 6-keto-$PGF_{1\alpha}$ (Campbell 1990). Biosynthesis of TXA_2 can be interfered with by long chain n-3 PUFA. Dietary n-3 PUFA can be incorporated into platelets, where they compete with AA for the 2-acyl position of membrane phospholipids (Dyerberg 1986, Leaf and Weber 1988). EPA, a long chain (LC) n-3 PUFA, is released from phospholipids of the platelet membrane, it competes with AA for access to cyclo-oxygenase and produces an alternative form of thromboxane, thromboxane A_3 (TXA_3), which is relatively inactive in promoting platelet aggregation and vasoconstriction (Raz et al. 1977). This situation can lead to a reduced TXA_2 production and thus a lower thrombosis tendency (Lands 1986, Dyerberg 1986). PGI_2 can also be produced from EPA in arterial endothelium *in vitro* (Dyerberg et al. 1978) and *in vivo* (Fischer and Weber 1984); PGI_2 has similar physiological actions and activity to PGI_2 (Moncada et al. 1976_a).

Numerous dietary intervention studies have found that TXA_2 production is more sensitive to alteration to the diet compared with PGI_2 (von Schacky et al. 1985, Mann et al. 1997, Ferretti et al. 1998). The ratio of urine excretion 11-dehydro TAB_2 to 6-keto PGF 1α was decreased by 20% when 34 healthy men aged 24 to 57 supplemented fish oil 15g/d for 10 weeks compared with placebo (48% of lard, 40% beef tallow and 12% of corn oil) (Ferritti et al. 1993). Daily urine excretion of 11-dehydro TAB2 was reduced by 14%, while 6-keto PGF 1α was decreased only by 2% when 25 healthy subjects (male 12, female 13) aged 22 to 52 years consumed an average 133g raw Atlantic salmon per day for two weeks compared with after one week vegetarian diet (Mann et al. 1997). When 8 healthy male volunteers aged 20 to 40 years consumed a high-DHA diet containing 6g/d of DHA for 120 days, 11-dehydro TAB_2 was decreased by 35%, while 6-keto PGF 1α was decreased only by 8% compared with the control diet with trace amounts of DHA ($n = 4$) (Ferritti et al. 1998).

Table 1. Nutrient intake during the low fat and high fat diets ($n = 27$)

	Low Fat Diet	High Fat Diet
Energy (MJ)	9.1 ± 1.6	9.3 ± 1.7
Protein (g)	87.4 ± 9.9	99.0 ± 12.3
Fat (g)	59.9 ± 9.1	103.3 ± 17.8
SFA (g)	19.3 ± 3.2	50.2 ± 8.7 **
MUFA (g)	23.6 ± 3.3	30.8 ± 10.6 **
PUFA (g)	12.5 ± 3.4	11.9 ± 3.0
P: S ratio	0.7 ± 0.2	0.2 ± 0.03 **
Carbohydrate (g)	307.7 ± 84.9	226.9 ± 47.7 **
Cholesterol (mg)	138.0 ± 18.5	341.6 ± 75.0 **
Fibre (g)	28.6 ± 6.4	27.9 ± 5.7
Alcohol (g)	5.1 ± 6.6	5.4 ± 7.4
Protein(% energy)	16.7 ± 1.9	16.5 ± 1.2
Carbohydrate(% energy)	55.0 ± 3.3	38.9 ± 2.9 **
Fat (% energy)	24.5 ± 2.2	41.3 ± 2:7 **