THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Report by Shimin Liu

2008 Churchill Fellow

THE CHURCHILL FELLOWSHIP sponsored by the CHURCHILL FELLOW’S ASSOCIATION OF WESTERN AUSTRALIA to study omega-3 fatty acids in animal derived food

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Executive summary
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The fellowship travel was undertaken between the 5th October and the 24th November, 2008. The aim of the fellowship was to visit a dozen of the institutions and principal scientists in Japan and China which carry out research on increasing omega-3 fatty acids in animal derived food products and production of functional foods. The information will be used to develop and modify CSIRO research project proposals and plans on omega-3 fatty acids enriched foods, and develop a project proposal for Meat & Livestock Australia funding assistance.

Highlights:
- Visited the National Institute of Health and Nutrition, National Food Research Institute and Japan Health Food & Nutrition Food Association in Japan;
- In China, visited the Key Laboratory of Dairy Sciences and Food College, Northeast Agricultural University; Institute of Nutrition and Institute of Subtropical Agriculture, Chinese Academy of Sciences; College of Life Sciences and College of Pastoral Agricultural and Grassland Sciences; College of Animal Science and Technology, China Agricultural University; and Institute of Animal Science, the Chinese Academy of Agricultural Sciences, and the National Key Laboratory of Animal Nutrition, and the Centre for Dairy and Dairy Product Quality of Agricultural Ministry.
- Meetings with about 20 researchers for discussions on the production of functional foods and their research progress.
- View their research facilities and potential collaborations in the future

Recommendations:
- Well nutrient-balanced diet and dietary intake is always the first line of defence towards good health. Reducing calorie intake in the Australian society should be an effective strategy for preventive health.
- Fortification of functional compounds in foods should be a better approach to supply these health-promoting compounds because they can be blended and balanced with other nutrients, and slowly digested and absorbed which avoids a potential stressor.
- Education on nutrition, health diets and preventative health is essential. The education could be delivered as courses in later stages of primary schools, and early stages of high schools. Some TV program about the knowledge of the dietary nutrition and relations to chronic diseases could be made, and broadcasted regularly.
- Plant-sourced omega-3 fatty acids remain the most important course in the livestock industry. Amongst them flaxseed is the best selection. Eucommiaceae, Linaceae, and Labiatae could be considered if they can adapt to Australian climate and soil conditions.
- Amongst animal species, chicken eggs appear to be a better way to deliver omega-3 fatty acids. CLA enriched milk from dairy cows and goats can be a good functional product.

Implementation and dissemination
Findings will be prepared in a paper which may be published in the Australian Journal of Experimental Research.
Introduction

The fellowship enabled me to travel to Japan and China in order to visit the leading research institutes in research on increasing omega-3 fatty acids in animal derived food products and production of functional foods. This report provides a summary of the information that I gained from the visit.

Consumption of more omega-3 fatty acid has been found to reduce the risk of the development of some chronic diseases. Chronic diseases, such as cardiovascular, respiratory and neurodegenerative diseases and cancer are major health problems in Australia. Evidence indicates that malnutrition over a long-term could be a significant contributor to these chronic diseases. There are two approaches that can be used to improve eating habits. One is well designed diets balanced in both macro- and micro-nutrients. The other approach is to produce and use functional food gradients; foods enriched with health-enhancing compounds such as omega-3 fatty acids and natural antioxidants. The average consumption of omega-3 fatty acids in the Australian society is low. There is a need to gain more of these essential fatty acids in our foods.

I extend my appreciation to the Churchill Trust and the Churchill Fellow’s Association of Western Australia for offering me this opportunity to pursue my enthusiasm in functional foods for improving human health. I am grateful to the members of the WA committee for their help in every aspect to allow my commitment to the Fellowship to be successful. My appreciations are also extended to the people listed on the Fellowship Program: without their friendships and supports, this visit would not have been successful. I am also grateful to the support of CSIRO Livestock Industries.

I greatly appreciate the strong support from my wife and our daughter. Your support is priceless, not only to my research for the Fellowship, but also to my difficult situations at work over past six months.
**Fellowship Program**

5th – 9th Oct, Tokyo, Japan
- visited the National Institute of Health and Nutrition (NIHN, www.nih.go.jp)
  - Dr Shaw Watanabe, director-general, NIHN
  - Dr Keizo Umegaki, director of Information Centre
  - Dr Kyoko Taku, project leader for information network of health food information centre
  - Ms Miki Miyoshi, public health nutritionist
- visited the National Institute of Health and Nutrition (NIHN, www.nih.go.jp)
  - Dr Toiro Tsusida, director of Food Function Division
  - Dr Takshi Ide, chief of Laboratory of Nutritional Function
- visited the Japan Health Food & Nutrition Food Association (www.jhnfa.org)
  - Dr Yuzo Hayashi, director general, pharmacist

10th – 14th Oct, Inner Mongolia, China
- visited the Inner Mongolian Agricultural University, and Inner Mongolia Yili Industrial Group Co., Ltd.
  - Prof Dr Dexun Lu, College of Animal Science and Technology, nutritionist
  - Dr Zhanyou Yun, Inner Mongolia Yili Industrial Group Co. Ltd.
- visit the Key Laboratory of Dairy Biotechnology and Engineering, the Ministry of Education (www.dairy-biotechs.cn), China
  - Prof Heping Zhang, Vice Dean, College of Food Science and Engineering, director of the Key Laboratory of Dairy Biotechnology and Engineering of the Ministry of Education, leading scientist in processing dairy products.
  - Prof Bilige Menghe, College of Food Science and Engineering, food chemist

15th – 17th Oct, Harbin, China
- visited the Key Laboratory of Dairy Sciences and Food College, the Northeast Agricultural University.
  - Prof Guicheng Huo, director of the Laboratory of Dairy Science, nutritionist and food chemist
  - Prof Lijie Yang, pharmacist and clinic nutritionist
  - Prof Xinghual Zhao, food chemist
  - Prof Baohua Kong, deputy Dean of Food College, meat product specialist

18th – 31st Oct, Shanghai, China
- attended the 14th International Conference on Food Science and Technology.
  - Business with Institute of Nutrition, the Chinese Academy of Sciences
    - Prof Yingying Le, food safety, preventive health, cytokines

1st – 9th Nov, Changsha, China
- visited Institute of Subtropical Agriculture, the Chinese Academy of Sciences
  - Prof Zhiliang Tan, nutritionist and animal health specialist

10th – 19th Nov, Lanzhou, China
- visited College of Life Sciences and College of Pastoral Agricultural and Grassland Sciences.
- Prof Zhibiao Nan, College of Life Science, and College of Pastoral Science, Lanzhou University
- Prof Ruijun Long, College of Life Science, and College of Pastoral Science, Lanzhou University

20th – 23rd Nov, Beijing, China
visited College of Animal Science and Technology, China Agricultural University
  Prof Yumin Guo, deputy Dean, animal nutritionist
  Prof Huiling Luo, animal scientist, meat products

visited Institute of Animal Science, the Chinese Academy of Agricultural Sciences, and the National Key Laboratory of Animal Nutrition, and the Centre for Dairy and Dairy Product Quality of Agricultural Ministry
  Prof Jiaqi Wang, deputy head of the Labs, expertise in dairy products and manipulating fatty acid compositions in dairy products.

24th Nov, Return to Perth, Australia
Visit in Japan

Established in 1920, and governed by the Ministry of Health, Labour and Welfare (MHLW), the Nutritional Institute of Health and Nutrition (NIHN) has made significant contributions to nutritional improvement in Japan. The research focuses include diet-related health issues, and safety and effectiveness of supplements and health foods.

The National Food Research Institute (NFRI), National Agriculture and Food Research Organisation (NARO) is governed by MHLW. The institute conducts research on food functions, resources, engineering, biotechnology, safety, analysis and standards. It operates mainly in three research centres: Food Function Research Centre, Food Safety Technological Development Centre and Food Analysis/Standardization Centre.

Japan Health Food & Nutritional Food Association is an industrial associated society. The association does research and carries out the surveys on the development, improvement and quality control of health foods and nutritional foods, promotes correct nutrition labelling, and promotes a cooperative, close working relationships with overseas counterparts and related institutions.

(1) Health issues in Japan (survey 2006):

There were 18.7 million (8.2 million with strong symptoms and 10.5 million with moderate symptom) diabetes mellitus.

Every second man and every 5th women were suspected to have metabolic syndrome or prodromal metabolic syndrome.

More then 30% of male aged 20-39 years and over 70% female aged 15-29 years are in the category ‘neither do not exercise nor even think of starting it’.

Obesity men (BMI > 25) ranged from 2.4% to 9.5% over 6 age groups (from 20 to over 70 years old). The underweight men (BMI < 18.5) ranged from 19.6% to 34%). The obesity women ranged from 4.4% to 21.7%, and the underweight from 7.7% to 26.6%.

Only 20% male and 30% female had more than 30% of dietary energy from fats. Average, they ate about 300-350g vegetables per day.

Therefore, metabolic syndrome is one of the national focuses in regards to health. Health issues in the western countries, such as cardiovascular diseases and overweight related obesity are not big problems here, mostly due to their dietary culture.

(2) Regulations (by the Ministry of Health and Welfare)
There are 3 categories of functional food products in Japan.

(a) Foods for special dietary use. This category is tightly regulated. It contains only four groups: for medical purpose, for pregnant women, for infants, and for the elderly.
(b) **Foods for special health use (FOSHIS):** This category includes foods in which a functional ingredient has been added for a specific health effect. The foods are designed to maintain and promote good health, e.g. improving intestinal conditions, reducing high cholesterol, reducing blood pressure, promoting mineral absorption, regulating blood sugar level, and non-cariogenic foods. On the label, it must state nutritional facts, health claims (enhanced functional claims) and warning statements. For products that do not require clinical evidence support, it falls into a sub-category.

(c) **Foods with nutrient function claims (FNFC):** It falls into the standard regulation system, and contains 12 vitamins and 5 minerals. On the label, it must clearly state nutritional facts and functions, and the warning statements.

**Foods with Japan Food Health Authorisation (JFHA) Mark.** Foods in this category are not regulated, but approved by the Japan Healthy Food & Nutritional Food Association. In 2006, there were 685 products based on 58 standards, covering proteins, lipids, carbohydrates, vitamins, minerals, fermented microflora, and algae. This category also includes herbs, plants, mushrooms and bee products. The standards consist of the definition, product standards (content of substrate and nutrient, safety and sanitation information, and daily intake), raw material standard and testing methods. The label contains the JHFA Mark.

(3) **Key issues**

The quantity of diet is usually small everywhere, which restricts daily calorie intake. This results in more people becoming underweighted, rather than overweighted, as shown in the 2006 National Survey.

A well balanced diet is always the first line of defence towards good health. This is the particular and clear warning for the use of functional foods.

Functional foods take appearances in usually food forms (powder, liquid, drink, cream), rather than in forms of tablets, pills and capsules which make consumers naturally link them to medicines and then expect medical effects.

Providing sufficient knowledge to the public by government services (more details of the functional compounds, accurate measures). For example, a website from the governmental...

The concept that foods and medicines share the same origin of health foods has been well accepted by the Japanese society. People look for foods in preventative health rather than rely on medicines.

Only a few products containing omega-3 fatty acids are in health product stores, it is not as popular as in Australia.

**Visit in Huhhot, Inner Mongolian**

The dairy production in the Inner Mongolian Autonomous Region has been growing rapidly over the past ten years, and now it has reached the leading position, as it is claimed “the dairy capital” in China. The industry is virtually dominated by two dairy companies: Yili Industries Group, and Mengniu (meaning Mongolian Cattle) Group. Their dairy products can show a general picture of the dairy industry in China. The companies have their own R&D Departments. In addition, the State government has funded a Key Laboratory on Dairy Product and Engineering to support the industry.

Inner Mongolia Yili Industrial Group Co., Ltd. is a flagship enterprise in China’s dairy industry, the largest public dairy company in China. There are 5 divisions: liquid milk, ice cream, milk powder, fermented milk and raw milk. The turnover of raw milk in 2006 was about 300 million tons. The company produces a number of dairy products enriched with special nutrients, such as omega-3 fatty acids (DHA), α-Lactalbumin and β-casein (most important proteins in breast milk), probiotics and trace minerals. There is an increase of demand and production of organic milk products: milk originally produced from the company owned farms where no chemicals have been used in the productive processes. Very low lactose milk products are also available to consumers who suffer from lack of lactase in the digestive tract. Due to a lack of natural sources of omega-3 fatty acids (from algae only), omega-3 fatty acids fortification is applied to the milk products only for infants in order to improve intelligence. The products for preventing cardiovascular diseases are not available.

The Key Laboratory, College of Food Science and Engineering has established a genome database of lactate bacteria, including more than 2000 strains collected from various places of North China. One specific strain, Lb. casei Zhang was screened out from a total of 240 stains. The stain is resistant to both acid (pH 2.5-3.0) condition and bile salt in vitro, and in a mouse model shows antagonistic to pathogenic E. coli in the intestine, modulates hyperlipidemia, enhances humour immune modulation, and has anti-oxidation effects. Techniques to culture and harvest high density of Lb. casei Zhang have been developed. This stain is currently studied intensively for industrial applications to healthy milk and dairy products.
Research on conjugate linoleic acid (CLA). CLA in human diets tends to reduce body fat, improves serum lipid profiles, improve immune functions, and may protect cells from oxidative damage. CLA in meat and milk is either directly from the rumen (only a fraction), or derived from 18C1, t11 fatty acid catalysed after desaturation by 9-desaturase in the mammary gland. Dietary type has an influence on CLA content in animal tissues and milk. Meat products from grass-fed ruminants are good sources of CLA, and contain much more CLA than those from grain-fed animals. Unsaturated fatty acids can be hydrogenated (or saturated) in the rumen by certain bacteria. Inhibition of this process could increase the substrate content for synthesis of CLA in the tissue or mammary glands. The current research focuses on the effects of the extracts of Asteraceae plants, such as artemisia L., cirsium Mill., andIxeris Cass. on hydrogenation of unsaturated fatty acids in vitro and on CLA concentration in milk when the extract is supplemented to diets for dairy goats.

Visit in Harbin
Northeast Agriculture University, Chian is the leading university in animal nutrition in the Northeast Region of China. The university holds the Key Laboratory of Dairy Science, Ministry of Education, and the State Centre for Dairy Engineering Technology & Research, State Centre for Dairy Product Quality Monitoring and Measures, State Centre for Dairy Product Standards, and State Centre for Dairy Product Information.

Back to the second half of the last century there was a big dairy industry in the northeast region of China. The leading position was gradually replaced by the Inner Mongolian Autonomous Region. Most of the research on dairy nutrition and products were conducted by the College of Animal Science, Northeast Agricultural University. The State government has funded the Key Laboratory of Dairy Sciences, and the university has established the Food College to strengthen R&D in the dairy industry in this region.

Functional compounds, such as antioxidants, omega-3 fatty acids, vitamins, and minerals, should be blended into foods to get the maximum benefits. There are some advantages. Readily to be taken by consumers is the obvious one. The compounds are diluted by food components, which avoids a high rate of clearance of these compounds by the liver that relates to a sudden increase of those compounds. It also reduces the potential imbalance between these compounds and other nutrients. Therefore there is a possibility that these compounds could work synergistically with other nutrients.

Omega- fatty acid eggs. Feeding hens with linseed meal resulted in high PUFA and omega-s in eggs. Linseed oil contains linoleic acid (18C2, n-6) 12.7%, and linolenic acid (18C3, n-3) 58.5%. Feeding hens with a diet containing 3% linseeds for 35 days resulted in omega-3 fatty acid content at 377 mg/egg, better than feeding a diet containing the same level of linseed oil. Chickens fed on a linseed meal diet had better meat quality (particularly flavour as the meat tasted much nicer), but unfortunately there was no objective measures on the quality.

Alpha-linolenic acid concentration may be increased in some fermented dairy products depending on the strains of the inoculators. Some bacteria can produce CLA. CLA content in milk varies between different species of mammals. The increasing order is horse, pig, human, goats, cattle, and sheep.

Current health product market: there are many health products on the markets. Most of them are sold in pharmaceutics stores, including omega-3 fatty acid capsules, mineral and vitamin
supplement tables, honey products, grape seeds products, and many Chinese herb products. The prices are high when the products are sold in pharmaceutics stores rather than in food stores. Comparatively, the omega-3 products are less popular in preventative health, apparently due to high prices and less acceptable compared to herb products.

The regulation system for functional or health products in China: Officially the policies and roles are made by the State Food and Drug Administration. They are all categorized as “Novel Source of Foods (Healthy Products)” in the system.

Visit in Changsha

The Institute of Subtropical Agriculture is the only institute in the Chinese Academy of Sciences that conducts research on animal health and meat quality. The Institute holds a Centre for Animal Health. The research of the Centre focuses on improving meat quality and functional meat products.

Post-rumen infusions of plant oils or non-esterified fatty acids can increase milk yield and milk fat content in goats. The fatty acid profiles in milk fat can be altered significantly depending on the fat or fatty acids infused.

It has been found that the content of 18C3 fatty acid in the meat had a high association with the flavour of the meat in ruminants.

Visit in Lanzhou

There are College of Pastoral Agriculture and Grassland Sciences, and the International Centre for Tibet Plateau Ecosystem Management in Lanzhou University. The research focuses include breeding novel pastures, pasture compositions, and the corresponding effects on milk and meat quality.

Amongst various species plants, Eucommiaceae, Linaceae, and Labiatae contain high level of α-linolenic acid. In particular, Eucommia ulmoides has oil content of about 32% with 42-62% of α-linolenic acid in the oil, Linaceae usitatissimum contains oil 30-44% with 42-60% α-linolenic acid, and Perilla frutescens contains 34-45% oil with 51-63% α-linolenic acid. The prices of these seeds in the market are reasonable.

Kiwi fruit (Actinidiaceae chinensis) contains 35% oil with 62% of α-linolenic acid in the oil.

A new bio-insect control system of using grazing chicken to control the breakout of grasshoppers in the grasslands has been developed. Interestingly, it has been found that α-linolenic acid content in the grasshoppers accounted for about 30% of the lipid, and the total content of polyunsaturated fatty acids amounted to about 47%. It is expected that omega-3 fatty acids in chickens grazing on the grasslands and live on both grasshoppers and green pastures will have high of omega-3 fatty acids in their meat.

Visit in Beijing

The Institute of Animal Science and Veterinary Medicine, the Chinese Academy of Agricultural Sciences holds the State Key Laboratory of Animal Nutrition, and the Centre for
Dairy Product Quality Monitoring and Assessment. Dr WANG Jiaqi is the leading scientist in
dairy nutrition and functional milk products in China.

CLA has functions of reducing the risks of cancers and artherosclerosis, increasing bone
density, regulating lipid metabolism and modulating immune responses. Increasing CLA
concentration in milk is an effective way in preventive health.

CLA in milk is either directly from the rumen (only a fraction), or derived from 18C1, t11
fatty acid catalysed after desaturation by 9-desaturase in the mammary gland. 18C1 fatty acid
is generated from biohydrogenation of linoleic and linolenic acids. Therefore, a high level of
18C2 fatty acid in the rumen results in an accumulation of 18C1, t11, or 18C1, t10 in the
rumen, and the increase outflow into the duodenum. Feeding dairy cows with feeds that
contain high levels of linoleic acid or linolenic acid can increase CLA significantly in a dose
dependent manner.

Fatty acids in feeds commonly used for dairy cows are dominated by C16, and C18 fatty
acids. Energy and protein feeds contain more C18:1 and C18:2 fatty acids, whereas forages,
particularly green pastures contain more C18:3 fatty acid. Roughages contain more saturated
fatty acids. It is possible to manipulate dietary gradients to enhance CLA concentration in
milk.

Adding fats in feeds, particularly in high yield dairy cows, can improve milk yield.
Adding fats enriched with unsaturated fatty acids is a main approach to increase the content
of unsaturated fatty acids in ruminants.

However, an oversupply of unsaturated fatty acids (>5% of the diet) may reduce the digestion
of fibres in the rumen by bacteria. More that 5% fat in diets may reduce dairy cow’s
performance as indicated by the declines in both voluntary fatty acids in the rumen and the
reduction of fibre digestibility. It can also reduce feed intake, which results in a reduction of
milk yield.

Recommendations

From what I observed in both Japan and China, as well as in Australia, well nutrient-balanced
diet and dietary intake is always the first line of defence towards good health. Reducing
calorie intake in the Australian society should be an effective strategy to preventive health.

Fortification of functional compounds in foods should be a better approach to supply these
health-promoting compounds because they can be blended and balanced with other nutrients,
and slowly digested and absorbed which avoids a potential stress.

Education on nutrition, health diets and prevent health is essential. The education could be
delivered as courses in late stages of primary schools, and early stages of high schools. Some
TV program about the knowledge of the dietary nutrition and relations to chronic diseases
could be made, and broadcasted regularly.

Plant-sourced omega-3 fatty acids remain the most important course in the livestock industry.
Amongst them flaxseed is the best selection. Eucommiaceae, Linaceae, and Labiatae could be
considered if they can adapt to Australian climate and soil conditions.
Amongst animal species, chicken eggs appear to be a better way to deliver omega-3 fatty acids. CLA enriched milk from dairy cows and goats can be a good functional product.