OCEANIAFOODS

Food Composition Data: Production, Quality and Evaluation

Proceedings of the 2nd Australia/OCEANIAFOODS Training Course and the 9th OCEANIAFOODS Conference

4-9 July 2016
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Introduction

Food composition data and databases are essential tools for food and nutrition professionals, especially those concerned with monitoring adequacy of dietary intake, for linking diet to health and disease, for diet planning and prescription, nutrition education and training, food safety, food security, and food trade, export and regulation. Quality of data is influenced by every step in the process of generation of data, starting from sampling, through analysis and quality assurance, to compilation of data.

A one-week training course on the production and use of food composition data in nutrition was coordinated by The University of New South Wales in cooperation with the Food and Agriculture Organization of the United Nations (FAO), and the European Food Information Resource Network (EuroFIR) in Sydney, Australia from 4-8 July 2016. The aim of this course was to demonstrate how to produce good quality food composition data and evaluate data for use globally, with an international perspective.

Following the course, a one-day meeting was held for course participants together with representatives of the OCEANIAFOODS grouping of INFOODS, the International Network of Food Data Systems, coordinated by FAO. Discussions were held on issues such as improving collaboration within the region and technical presentations on the importance of data quality and evaluation in nutritional epidemiology, dietary surveys and critical nutrient data issues in Oceania related to fortification of foods and other issues.

These proceedings combine presentations held at both the course and meeting.

The organizers of both events would like to show their respects and acknowledge the Bedegal people who are the traditional custodians of the land, of elders past and present, on which this course and meeting took place.

Associate Professor Jayashree Arcot
Director, ARC Training Centre for Advanced Technologies in Food Manufacture

Welcome

Judy Cunningham, OCEANIAFOODS Coordinator

The 9th meeting of the OCEANIAFOODS composition group was the first since 2009. That meeting was also held at The University of New South Wales. I am sure all course and meeting attendees will join me in thanking Professor Jayashree Arcot and her team for organizing this meeting.

When the regional groupings of the INFOODS program were set up, it seems that countries were grouped primarily on geography and the countries that border the south-west and central Pacific were formed into the OCEANIAFOODS group[1]. Oceania is a very diverse region in terms of size, population groups, climate and agricultural systems, level of development, public health challenges and eating patterns. What unifies us apart from our location in or around the southern Pacific Ocean and a shared love of rugby football?

Perhaps it is easier to define what unifies us by highlighting what we lack – population. The OCEANIAFOODS regional grouping covers a vast area, with a population much smaller than other regional groupings and with great disparities in national wealth. With a land mass of approximately 8.5 million square kilometres and a population of approximately 40 million, Oceania is roughly twice the size and has less than 10% of the population of our regional neighbours, the ASEAN countries[2]. Ninety percent of the population is found in only three member nations – Australia, Papua New Guinea and New Zealand. Gross Domestic Product (GDP) ranges from less than US$2,000 per person (Solomon Islands, Kiribati, 2015 estimates) to more than US$40,000 per person (Australia, New Zealand). Indigenous populations include Melanesians, Micronesians, Polynesians and Aboriginal and Torres Strait Islanders (DFAT, 2016), but they share Oceania with a large number of migrant peoples whose origins lie in other parts of the world.

It is clear from this rudimentary analysis of our small population that our region faces a huge challenge in building a critical mass of researchers, food composition data users and funders across the region. Furthermore the vast distances between countries means that transport is expensive and slow, even in the age of air travel. It is not easy to organize a meeting with people from even half of our member countries, even if we had the funds to pay for representatives of all Member States to attend.

This highlights a second unifying factor in the region – lack of resources. Even in a country as wealthy as Australia, funds to support basic science research are small. So what can we possibly expect from many other countries in our region where national GDP is much lower?

At the same time as lack of funds, Oceania as a whole faces huge public health and environmental challenges. Our region, especially our island nations, will bear the brunt of the effects of climate change on land, population and agriculture (for example, see Mantesso, 2016).

1.The Member States of OCEANIAFOODS are American Samoa, Australia, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn Island, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna (FAO 2016).
2. The Member States of ASEANFOODS are Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam

We face public health challenges of not enough food through to excess food consumption. For example World Health Organization (WHO) statistics show that in 2011 almost half of children under 5 years in PNG had stunted growth. Fourteen percent of the PNG population has an energy intake below minimum levels required. In Vanuatu in 1996, the most recent WHO data point, 57% of pregnant women had anaemia (WHO, 2016). However, diseases of over-nutrition are also growing through the region and in Australia almost 2 in 3 adults are overweight or obese (Australian Bureau of Statistics, 2012).

And yet food composition data are fundamental to understanding the solutions to some of these problems. Food composition tells us which local foods are high in iron and energy. It tells us which plant varieties are rich in micronutrients and could be favoured in plant breeding and to support biodiversity. It helps us to determine whether programs such as food fortification are needed and, if so, to monitor whether or not they are working. If we think of food composition as not only limited to nutrients, then our data can tell us which foods may be high in contaminants or rich in other potentially beneficial components. Culturally they help us to understand the importance of some of our traditional ceremonial foods, and food composition data help us to educate our people through tools such as food labels.

The Oceania region needs good quality food composition data.

The 9th OCEANIAFOODS meeting focused on quality in food composition. We heard about a range of different quality aspects. Quality is relevant to the smallest and simplest of food composition studies and is not confined to large scale and expensive activities. Quality was also the theme of the regional food composition training course that was just held at The University of New South Wales. It is relevant to everyone at both the course and the meeting.

I hope that this meeting, and its Proceedings, inspires attendees and readers to think how the work they are doing fits in with the data needs for the Oceania region and to consider if even a part of this work could be relevant to other countries. In Oceania our small size means we have to get smarter at working together.

But I also encourage us to think how we can also link into the amazing expertise of our INFOODS neighbours, because in today's global food supply we share much in common with our neighbours. I am therefore particularly pleased that we had some participants from the ASEANFOODS area at this meeting.

Finally I would like to ask you to think about how you can promote the importance of food composition data to funders and other organisations and help to build quality data that are relevant to our entire region, not just in Australia and New Zealand. OCEANIAFOODS needs a new coordinator and also appointment of country coordinators if we are to overcome the problems of low population and limited funds.

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The whole food system approach when developing food composition data. An INFOODS view

U. Ruth Charrondiere,
Nutrition Officer and INFOODS coordinator, FAO, Rome

Introduction

New approaches are needed to adequately feed the world population today and in the future and to decrease malnutrition rates significantly. In addition, existing high pressure from different parts have to be taken into account such as population growth, climate change, limited natural resources or restricted possibilities to increase agricultural productivity. In many countries the different sectors, such as health or agriculture, have acted independently and sometimes contradicting each other. Agriculture has emphasized quantity and monetary value of agricultural production while some nutritionists worked with consumers trying to motivate them to eat diverse and healthy foods, while others opted to reach nutrient adequacy though staples, a low dietary diversity and fortification or supplementation programmes.

Recognition of the importance of diversified diets, biodiversity and the food system approach is growing at global and regional levels: the Framework for Action of the Second International Conference on Nutrition, the International Scientific Symposium on Biodiversity and Sustainable Diets United Against Hunger, the recently adopted Voluntary Guidelines for Mainstreaming Biodiversity into Policies, Programmes and National and Regional Plans of Action on Nutrition of the FAO Commission on Genetic Resources for Food and Agriculture.

Food and malnutrition

It is becoming widely accepted that mono-sectoral work did not lead to a significant reduction of malnutrition, diet-related diseases and food and nutrition insecurity. More recently, a shift towards holistic approaches are seen on the global arena. The food system approach is found to be more efficient as it tackles simultaneous all activities related to the production, processing, distribution and consumption of food that affect human nutrition and health. This shift cannot be achieved successfully without accurate data on the quantity and quality of nutrients provided through the foods consumed, particularly local foods. In order to design and implement effective and sustainable policies, programmes, projects or interventions in nutrition-sensitive agriculture or nutrition based on foods, it is essential to know the nutritional composition of the foods to be produced or consumed.

In addition, there is increasing evidence (Latham, 2010) that: "Vitamin A (capsule) programmes are ineffective. They use up precious human and material resources. Most of all, they impede

other approaches to the prevention of vitamin A deficiency [...]. These include breastfeeding, and the protection and development of healthy, affordable and appropriate food systems and supplies. Such approaches also protect against other diseases, are sustainable, enhance well-being, and have social, cultural, economic and environmental benefits." Often, the traditional, biodiverse or local foods, which were or are being replaced by more modern and convenient foods, had high micronutrient contents, such as the orange-flesh bananas or taro in Micronesia (Engelberger, 2011). And this shift entails poorer nutritional status and higher rates of malnutrition. Therefore, in the AFROFOODS (2015) and Hyderabad INFOODS (2015) declarations, a return to local foods and varieties is promoted but also the analysis of their nutrient composition as this information will help to argue their importance not only in a cultural context but also nutritionally and health wise.

The need for food composition data

Food composition data are fundamental for any nutrition activity and are necessary for sustainable and nutrition-sensitive food systems. But in many countries, these data are missing or are borrowed from elsewhere, often without documentation, and may not represent the foods consumed. Therefore, many nutritional challenges persist and the foods potentially able to reverse malnutrition are not produced, traded or consumed, one reason being that nobody values them because, among others, their nutritional compositions are unknown and the additional stigma of being a poor man's or drought food does not help to promote these foods through any official or unofficial channel. If nutritionists, agriculture professionals and politicians would be more convinced of the value of high-quality and relevant food composition data for nutrition and agriculture and the improvements through avoiding inefficient but costly programmes and policies, more analytical data would exist on the composition on all nationally important foods but also on less-consumed foods with good nutrient profiles, being able to make the difference between nutrient adequacy and inadequacy.

However, in most countries in the world the available compositional data provide fragmented if any data on the composition of the foods consumed by populations, and this is worse for biodiverse, local and processed foods or commercial products. In many developing countries, the compositional data available in published food composition tables or databases (FCT/FCDB) are borrowed from similar-seeming foods from developed countries, which might have much lower nutrient contents compared to the local foods. For example, when analysing dark green leaves from Africa, the iron content per 100 g edible portion (EP) on wet weight basis, ranged from 3.9 to 16.2 mg. Normally, in the absence of data, the iron value of spinach from the USDA database would have been taken (2.71mg iron/100g EP) leading to an underestimation of nutrient intake. For this reason, the assessment of nutrient adequacy might give a worse picture than it actually is, in this case due to underestimations of nutrient intakes and a flattening of nutrient intake distributions through random errors in FCTs.

The food composition community has not been able to convince donors to invest in analysis of the nutrient contents of foods. In general, in developed countries more foods are analysed compared to developing countries. Africa seems to be the continent where the available FCTs

are the least equipped with recent analytical data and where most biodiverse or local foods, if listed, normally have food composition data estimated based on similar foods from FCTs from developed countries. As the above example of iron in African dark green leaves showed, the borrowing of data from foreign countries' sources might lead to significant underestimations of nutrient intake estimations and a non-promotion of local dark green leaves as they would have been considered to have a low iron content and thus would leave them undervalued by the local population and governments. Anaemia could be prevented by promoting the local iron rich foods, instead their consumption is decreasing and is being replaced by foods with even lower iron content, aggravating the already important public health problem represented by anaemia. There are many more examples like that where local foods are undervalued and less consumed instead of being promoted and grown in larger quantities, just because of the lack of analytical food composition data indicating their beneficial nutritional content. And malnutrition rates continue to be high.

There are some positive examples recently where investments in analysing foods and/or compilation of existing analytical data are taking place. For example, FAO Kenya has allocated US$400,000 to update the Kenyan FCT, including chemical analysis. Ghana is collecting available analytical data for the update of the West African FCT, as part of the International Dietary Data Expansion (INDDEX) project (2015-2017), and is analysing foods sponsored by the World Food Program and a private company. FAO/INFOODS is compiling analytical data from all over the world and publishing them regularly since 2010 in the FAO/INFOODS Food Composition Database for Biodiversity (FAO, 2016a), now containing values for 8000 foods and 450 components, as well as in the FAO/INFOODS Analytical Food Composition Database containing compositional data for 1360 foods and 322 components. These data can serve as the basis for inclusion of biodiverse foods into national FCTs or for agriculture to decide which varieties and species have a better nutrient profile compared to others. It is to be noted, however, that these databases do not include complete nutrient profiles as national FCTs do but they represent a unique collection of purely analytical data. It is planned to increase the coverage of foods over time.

Across all foods, analytical vitamin data are missing. And they are so important and likely to vary significantly across varieties and countries. This is truly a big knowledge gap.

Biodiversity and adequate nutrition

Biodiversity is defined here as the intra-species biodiversity (in nutrition simply called biodiversity) is adding a new dimension by considering foods below species level (i.e. varieties, cultivars and breeds) as well as wild, neglected and underutilized species (NUS). Biodiversity can really make a significant difference in nutrient intake and nutrient adequacy as variations in nutrient content between species can be as high as within species (up to 1000 times). For example, consuming a 100 g banana can thus contribute to less than 1% of vitamin A requirement or to over 200% depending on the variety consumed which can contain between 26 and 8508 mcg beta-carotene per 100 g edible portion.

FAO has calculated that vitamin A deficiencies could theoretically be eliminated globally if the varieties of cassava, potato, sweet potato, taro, mango, apricots and bananas with the highest vitamin A content would be planted and consumed. The argument could be that those varieties with high vitamin A content could be those with low yield. Yield and nutritional content are two key parameters, one for nutrition and one for agriculture. Putting both together into one concept would help both professional groups to better understand each other's need and objectives. Having this in mind, FAO is developing the nutrient productivity concept (FAO 2016b; Charrondiere 2016), which combines yield with the composition of nine nutrients (energy, protein, dietary fibre, Fe, Zn, Ca, vitamin A, vitamin C and folate) and relates them to the nutritional needs (DRI – Dietary Reference Intakes) of humans. The nutrient productivity is expressing the percent of DRI to be met for 10 adults per year from an agricultural product produced in one hectare per year, either for one or all nine selected nutrients. Preliminary results show that it is useful to combine yield and nutrition composition in order to decide which varieties to grow, with a nutrition-sensitive perspective instead of only considering yield. Even if only energy is considered in the nutrient productivity concept, as it is done in many settings, potatoes and bananas have a higher score compared to cereals. If all nine nutrients are considered, potatoes and banana remain high, and cereals become equivalent to legumes. Animal products have in general lower scores while milk and eggs give better results compared to meat.

The question arises: if some varieties or underutilized species are so rich in nutrients which are lacking in our food supply and cause millions of people to suffer from micronutrient deficiencies, why are they not consumed or produced more? The answer starts with agricultural practices which favour three crops (wheat, corn, maize) and the big five animals (cattle, pigs, chickens, sheep and goats) for research, production, subsidies, marketing and food security. Other species are neglected in these aspects, including biodiverse foods, and thus have poor economic competitiveness, lower productivity, yield, income and marketing possibilities, and can be more labour intensive in the production and/or processing. They are therefore in danger of getting lost as they are not used in mainstreamed agriculture. Additionally, they often are replaced by Western style diets and have the stigma of being the "food of the poor". Again, if their nutrient composition would be known and nutrition-sensitive agriculture would be more wide-spread, these local or biodiverse foods could be more valued and be included in agricultural research programmes and thus would be more likely to enter the mainstreamed agriculture and eventually be consumed more.

A multi-sectoral approach to malnutrition

Increasing agricultural production alone is, however, unlikely to make a difference in malnutrition rates if the marketing opportunities and the consumption of these nutritious foods are not increased. Therefore, value chains and distribution channels as well as processing possibilities have to be explored and improved to make them accessible to consumers, hopefully at a decent price for consumers and producers. In addition, consumers need to be made aware of the benefits of these foods through promotion campaigns and nutrition education programmes. And this then closes the cycle of the food system: from production, processing, distribution and marketing to consumption.

The stakeholders in the food system approach are multiple which call for multi-sectoral approaches and collaborations. In the past, this has hardly happened. Nutrition concentrated on

consumers, agriculture on yield and economic benefit, and distribution and processing was often left to the private sector. Education, technology, environment, biodiversity or finance were rarely considered. A truly multi-sectoral approach is challenging in most countries but is probably the only way to truly make sustainable improvements in malnutrition. It is hoped that the shift in this direction will lead to common and coherent goals among different policies to achieve better food-based nutrition through using existing biodiversity, especially for micronutrients. In order to do that, decision makers need to know what the different foods contain, including processed or biodiverse foods, and not only for macronutrients and minerals but also in terms of vitamins and bioactive compounds. However, data on vitamin and bio-active components are lacking for almost all foods as these analysis are expensive.

In recent years, the importance of the gut and its health is being recognized. It will add a new dimension in nutrition as the microorganisms in the gut can produce some nutrients depending on which foods reach the gastro-intestinal system.

Conclusion

In summary, food composition data are key for developing and implementing programmes and policies for nutrition and nutrition-sensitive agriculture, especially if embedded in a food system approach. More chemical analysis of foods is needed, especially of vitamins, not only in developing countries but also in developed countries. In order to diminish malnutrition rates sustainably, a multi-sectoral approach is essential with nutrition and agriculture in the centre. In the future, agriculture might not only become a major user of food composition data but might also become a major donor. The nutrients which are not present through agricultural production, cannot be preserved through processing or trade and therefore cannot be consumed through foods.

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Country reports

Country Report – Australia

Renee Sobolewski, Senior Scientist,
Food Standards Australia New Zealand

Background

This paper focuses on the following:

- The food composition program at Food Standards Australia New Zealand (FSANZ)
- Food composition activities in Australia since the last OCEANIAFOODS meeting in 2009
- Major challenges for food composition work in Australia.

There are a number of Australian universities and organisations that carry out food composition activities in Australia, including universities such as the University of New South Wales, University of Wollongong, and University of Sydney; research institutes (such as the George Institute) and industry groups (e.g. Meat and Livestock Australia, Grains and Legumes Nutrition Council). Data generated is used in a wide range of activities and often provided to FSANZ. FSANZ publishes the national food composition tables – NUTTAB (a reference dataset; FSANZ 2011) and AUSNUT (a nutrition survey dataset; FSANZ 2014).

FSANZ food composition activities since 2009

The food composition team at FSANZ is a small team of professionals with training in nutrition, food science, food production and chemistry and extensive experience in scientific data compilation and applications. Staffing of the team tends to be somewhat fluid, as staff enter and leave the team depending on other work priorities in the agency and as funds permit. Where possible, there is involvement with international food composition activities.

FSANZ funds its food composition activities from its general budget and does not receive any funding specifically for this activity. Therefore funding for nutrient analysis needs to 'compete' with other internal projects within the constraints of the agency's modest overall budget and need to meet its statutory objectives. The only exception to this in recent times has been that the Australian Bureau of Statistics (ABS) provided funds to support FSANZ participation in the 2011-13 Australian Health Survey (AHS), although FSANZ also contributed significant resources, in recognition of the importance of being involved in this project in terms of our subsequent use of the data in dietary exposure assessments.

The major areas of FSANZ food composition activity since 2009 have been:

1. Release of NUTTAB 2010, the latest release of the national reference dataset for nutrient data (FSANZ 2011). NUTTAB 2010 contains nutrient data for 2,668 foods available in Australia and for up to 245 nutrients per food.
2. 2011-13 AHS, leading to the release of AUSNUT 2011-13 (FSANZ 2014) and the recent release of accompanying datasets on free and added sugars, and Australian dietary guidelines core food groups (FSANZ 2016a, b).
3. Analytical programs (see below).
4. Work on redeveloping NUTTAB for its next release, and the online nutrient labelling tool, the Nutrition Panel Calculator (NPC).
5. Work on redeveloping the data management system that supports all the FSANZ food composition publications (see below).

Since 2009, FSANZ has conducted 20 analytical programs, generating nutrient data for approximately 260 foods. These programs, which were often quite small, focused on re-analysis of commonly consumed foods (e.g. milk, bananas), "new" foods (e.g. spelt flour, baby spinach and rocket), foods where existing data were outdated or limited (e.g. some fruits and vegetables such as avocado, tomato, beans, oranges) and foods that allowed verification of AHS recipe assumptions (e.g. common cakes). There was also significant activity associated with the monitoring of mandatory fortification of bread-making flour with folic acid, and of iodised salt used in bread-making. Reports and summary of the data from these studies is on the FSANZ website (http://www.foodstandards.gov.au/science/monitoringnutrients/Pages/default.aspx).

FSANZ was also provided with data from 11 analytical programs conducted by the food industry and research groups. The data from these programs largely focused on meat, seafood, grains and legumes, native foods and mushrooms. FSANZ has developed some guidelines to assist with the design of analytical programs provision of data to FSANZ (available at http://www.foodstandards.gov.au/science/monitoringnutrients/nutrientables/Pages/default.aspx).

Future activities

A new version of the reference dataset, NUTTAB, is due for release in 2017. It is being developed using new data for foods analysed for AUSNUT 2011-13 and will include features such as:

- a public food key (identification code) that is consistent across different datasets
- dataset from all analytical programs undertaken since 2010
- a set of 53 core nutrients, including added sugars, based on those currently in AUSNUT
- the derivation of each value (i.e. whether the value was analysed, recipe calculated or imputed)

- the number of data points used to determine each value (for analysed values)
- values reported based on common measures in addition to per 100 g/mL
- new look interface.

A revised NPC dataset is also expected to follow in 2017.

Supporting the new format of NUTTAB and the NPC will be a new data management system, named Silo. Silo will replace the current data management system, the Australian Nutrient Databank (ANDB). Silo will enable more streamlined data compilation processes; easier reporting and interrogation of data; changes to food profiles to be more easily tracked over time; and will facilitate use of food composition data in Harvest, the database used by FSANZ for dietary exposure assessment (see http://www.foodstandards.gov.au/science/exposure/Pages/fsanzdietaryexposure4439.aspx), and also on the FSANZ website.

A longer term goal is to use Silo to store all of FSANZ food data, including data for contaminants, food additives, agricultural and veterinary chemicals, and levels of microorganisms.

Major challenges for food composition in Australia

Challenges faced by FSANZ and others working in this area include:

- Funding for a longer-term program that supports regular updates of nutrient data and timely releases of those data to users
- Finding and maintaining staff with specialist skills
- Maintaining current and complete nutrient data as the food supply changes, because of the high costs associated with nutrient analysis and the need for advanced analytical facilities and training.
- Ensuring nutrient databases meet user needs and keep pace with changes in information and communications technology.

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Country Report - Fiji

Dr Jimaima Lako,
Fiji National University

Background

This paper outlines major activities related to food composition, and food and nutrition, which have taken place in Fiji since 2009.

Major players in this area in Fiji are:

» The Institute of Applied Sciences (IAS) at the University of the South Pacific (USP), which conducts food composition and microbial analyses.

» The Ministry of Agriculture - Koronivia Research Station, which conducts some food analyses (especially proximate composition) and value-addition.

» The Food and Nutrition Centre of the Ministry of Health and World Health Organization (WHO), which conduct health surveys and food and nutrition status surveys.

» The Pacific Research Centre for the Prevention of Obesity and Non-Communicable Diseases (CPOND) at the Fiji National University, which focuses on non-communicable diseases (NCD) research.

Major activities undertaken

Table 1 summarizes major activities taken since around 2009-2015 by the main groups in Fiji. These activities include:

» Value-addition and food product development through the Pacific Island Forum Secretariat (PIFS) and Secretariat of the Pacific Community (SPC) through aid funding e.g. seaweeds, virgin coconut oil (VCO).

» Secretariat of the Pacific Community – EU-EDES[3] / Laboratory Management System and Quality Assurance, including quality control training for food industries, for laboratory staff from the Institute of Applied Sciences and Ministry of Agriculture - Koronivia research station and from other private sectors.

» Secretariat of the Pacific Regional Environmental Programme (SPREP) – Chemical management for the 14 countries of the Pacific region.

» Centre for Technical Agriculture Development Netherlands (CTA), The University of the South Pacific (USP), World Health Organization (WHO) and International Trade Centre (ITC) - Food Safety.

3. The EDES program is a European Union funded project that aims to improve food safety standards in developing countries in order to increase their trading capacity and ultimately reduce poverty rates (Goetz, 2010)

Major challenges and opportunities for food composition in Fiji

The Pacific Island Food Composition tables (Dignan et al., 2004) are too limited and do not address the types of nutrient data required to help inform activities for dealing with non-communicable disease, such as data on glycaemic index or response (for diabetes), flavonoids and carotenoids (for cancer research) and data on folates and other micronutrients (for dealing with micronutrient deficiencies such as anaemia).

Relevant institutions tend to work in isolation with minimal collaboration, resulting in mismatches between food composition innovations and resolution of food and nutrition issues. IAS work focuses on routine analyses such as the food industry requirements for nutrition labelling and does less work than before on food composition analyses, for example, β carotene levels. Even intra-departmental collaboration within the same institution is minimal. Higher degree research findings, such as data on folates, phytochemicals and antioxidants in Pacific foods, and levels of nitrates and nitrites, are not incorporated into the food composition tables. Given the limited funds available within institutions, researchers must rely heavily on external funds for development.

The Pacific Food Composition Tables are not only limited in the varieties of Pacific Islands' foods but also in imported foods. Studies (Snowden et al., 2013) have shown that Pacific Islanders are consuming a lot of imported foods and some countries are dependent on imports to achieve food security; hence the inclusion of more varieties is important.

Method development in laboratories is quite costly; hence Fiji laboratories need a market or clients to be able to obtain a profit or even to recover the cost spent in method development.

The discontinuation of the course for the degree of Bachelor of Science in Food and Nutrition at USP will likely affect regional development and research in food science and food security aspects.

There are opportunities to expand the Pacific Food Composition tables to include:

- Additional foods, particularly imported foods that are not yet in the table
- For local foods, data on different, common varieties rather than composite data covering a range of varieties
- Bioactive components e.g. flavonoids, antioxidants
- Fatty acid profiles, including trans and essential fatty acids
- Allergens and contaminants
- Salt and sodium.

Table 1. Summary of major food composition activities in Fiji, 2009-2015

Year	Institute of Applied Science (IAS) and University of the South Pacific (USP)	Ministry of Agriculture - Koronivia Research	National Food & Nutrition Centre, Ministry of Health & WHO	Centre for the Prevention of Obesity and NCD, Fiji National University
Prior to 2009	Compilation of Food Composition Table Continued with food nutrients, heavy metals, histamine accreditation		Salt, fat and sugar reduction campaign and consultations Micronutrient survey in children	
2009		Agricultural census	Nutrition Guidelines for Schools	Established
2010	Trans fatty acid analyses (MSc research)	Food Security: » Import substitution » Food Product Development and Value-addition Plan for the upgrade of Food Lab	NCD steps WHO survey Impact Study of Flour Fortification (15-49yrs)	Salt intake survey
2011-2012	Biofuel Lab set-up with Fiji Govt (IAS)	Continuation of activities above	NCD Prevention and Control Strategic Plan 2010-2014) Fiji Plan of Action on Nutrition (FPAN) Activities (2011-2015)	
2013	Development and launched of a new Kava Drink – with Taki Mai strengthens – kava lactone analyses (IAS)	Continuation of activities above	Fiji Plan of Action on Nutrition (FPAN) Activities (2011-2015)	Snowdon & Thow 2013. Snowdon et al. 2013
2014-15	Trans fatty acid analyses (IAS) (WHO intends to make this a compulsory item in the nutrition information panel). Drug discovery on antibacterial, antifungal and anticancer from marine and terrestrial samples Ciguatoxin (USP research) Microbial accreditation achieved	Fiji Green Growth Framework Fiji 2020 Agriculture Sector Policy Agenda: Modernizing Agriculture	National nutrition survey	Salt content of foods

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Country Report – New Zealand

Siva Sivakumaran (presenting author), Subathira Sivakumaran and Lee Huffman,
New Zealand Institute for Plant & Food Research Limited

Introduction

Plant & Food Research (PFR) is a New Zealand-based science company providing research and development that adds value to fruit, vegetable, crop and food products. PFR employs nearly 900 people based at sites across New Zealand, as well as in the USA and Australia. We collaborate with more than 100 organizations globally, and have formal relationships with a number of research institutes designed to further research in specific areas of beneficial interest http://www.plantandfood.co.nz/.

The New Zealand Food Composition Database (NZFCDB) is the major source of food composition data (FCD) in New Zealand. The NZFCDB is jointly owned and funded by the New Zealand Ministry of Health (MoH) and The New Zealand Institute for Plant & Food Research Limited (PFR). The partnership between PFR and MoH was initiated in 1989, with responsibility for the NZFCDB residing with the Department of Scientific and Industrial Research (DSIR). With the dissolution of the DSIR in 1991 and formation of Crown Research Institutes, the New Zealand Institute for Crop and Food Research (Crop & Food Research) managed the NZFCDB. In 2009 the Institute for Crop and Food Research and HortResearch (The Horticulture and Food Research Institute of New Zealand Limited) merged and formed PFR. Since then there has been significant development of the NZFCDB.

The NZFCDB has three main internally developed components:

1. the database itself – a relational database (Microsoft SQL Server) with some executable stored procedures;
2. the Food Information Management System (FIMS) – a Java-based web application and the primary data entry and editing mechanism for NZFCDB; FIMS also contains the codes for recipe and attribute calculations;
3. NZFCDB Auxiliary – a PHP-based web application that runs independently of FIMS for generating NZFCDB-associated products, and enabling bulk data entry.

Programme Outcomes Current NZFCD products

A number of useful information products are generated from the NZFCDB. These are the primary mechanism by which the data are made available to consumers; the database itself is not publicly accessible at present.

NZFCDB website (www.foodcomposition.co.nz)

The NZFCDB-derived NZ FOODfiles have been updated 19 times since 1989, and The Concise New Zealand Food Composition Tables (Concise Tables) have been updated 11 times since 1993. The last three updates (2011, 2013 and 2014) and the current version (2015) are freely available on our website www.foodcomposition.co.nz (The New Zealand Institute for Plant & Food Research Limited, 2011). Earlier versions of these products (1989–2006) were published on CD-ROM and as printed Concise Tables.

From November 2011, NZFCDB-associated products have been freely available on the website (The New Zealand Institute for Plant & Food Research Limited, 2011).

NZ FOODfiles

The New Zealand FOODfiles 2014 Version 01 (The New Zealand Institute for Plant & Food Research Limited, 2015) contains eight files (Figure 1). These are available in two formats: as tilde-delimited ASCII text files and as Microsoft® Office Excel® files. The data files contain 87 core components for 2574 foods in the standard version, and up to 360 components for 2574 foods in the unabridged version. The unabridged version and some of the food records in the standard version do not contain values for every single component for every single food.

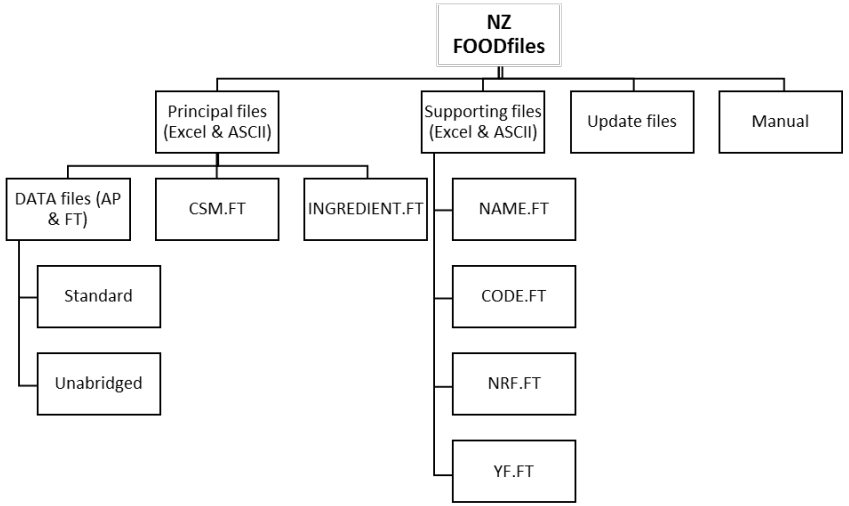

Figure 1. New Zealand FOODfiles download layout

All 2574 foods have complete datasets for the 65 core components as of 2014, including energy, proximate components, vitamins, minerals, derived components (edible portion) and other components (e.g. caffeine and cholesterol). The individual fatty acids values are not reported for some of the foods, and the fatty acid profiles also differ. The remaining core components have

data for limited foods. These are alpha- and beta-carotenoids (75% and 83%, respectively), omega fatty acids (14–47%), soluble and insoluble dietary fibre (53% each), tocopherols (10–60%), tryptophan (41%) and common standard measure CSM (92%). In the current programme (2015–16), all foods have complete sets of data for the 87 core components.

The DATA.FT file provides information on derivation source/s for each food component (identified with component identifier). DATA.AP is an alternative format of the DATA.FT file and contains additional information including food group code, food name, component name and unit(s) of measurement. In the CSM.FT file the measures are expressed either as New Zealand metric standards, or as the amount commonly purchased or eaten. All the measurements are made on an edible portion, so no adjustment is necessary to account for an inedible portion. The CSM.FT file also contain densities for most of the foods. It should be noted that there may be more than one CSM for any particular food. The INGREDIENT.FT file contains the FoodIDs of the recipes and associated ingredient/s and their food names. It also contains the fraction (%) of the ingredient, the identifiers (ID) for the nutrition retention factors (NRF) and cooking methods used in that particular recipe.

The NAME.FT file includes information on names associated with each food, e.g., common name (generic, kind, and strain), parts, process, scientific name, description of the food (fortification, origin, ingredients, etc.) and sampling and component details. The CODE.FT file contains list of the food components, component identifiers include INFOODS tagnames and units of measure. The NRF.FT file contains the NRF for selected nutrients and associated IDs used in INGREDIENT.FT files. The YF.FT files provide the data for Water YF, Fat YF and Weight YF for the foods derived by the recipe calculation method. Also included is the source code for Weight YF.

Updated files indicate changes from the previous version of the FOODfiles, including new foods added, archived foods, and food components updated.

The FOODfiles manual (Sivakumaran, Huffman, Gilmore, & Sivakumaran, 2015) provides instructions on how to use the FOODfiles and other NZFCDB-associated products.

Concise Tables

The Concise New Zealand Food Composition Tables provide information from NZFCDB in PDF and Microsoft® Office Excel® file formats (Sivakumaran, Huffman, & Sivakumaran, 2015a). They contain data on selected nutrients for a subset of foods and are intended to provide a quick reference. The latest version (11th Edition 2014) contains data for 36 components of 1013 foods. Nutrient information is based on both a 100-gram edible portion and one or more CSM for each food.

Nutrition Information Panel

The New Zealand FCD for Nutrition Information Panel (NZFCDB-NIP) is an online tool (The New Zealand Institute for Plant & Food Research Limited, 2015) designed to assist food manufacturers in estimating NIPs for their products. It presents seven mandatory components — energy, protein, fat, total, fat saturated, carbohydrates, sugars, sodium and dietary fibre — for

2574 food records according to Standard 1.2.8 of the Australia New Zealand Food Standard Code (Food Standards Australia New Zealand, 2012). It also includes a search function for matching specific keywords or Food IDs.

Food analysis in the NZFCDB programme

Most of the FCD in NZFCDB are mean data from a representative composite sample. These data do not show how variations among regions, seasons, cultivars, and other factors that affect the composition of most foods. However, the procedure does take potential variability into consideration when producing a single set of data for a food record (Sivakumaran, Huffman & Sivakumaran, 2015b).

From 2011 to 2014, 560 food records were added to or updated in the NZFCDB. They were disseminated in NZFCDB-associated products on our website in April 2013, 2014 and 2015 (The New Zealand Institute for Plant & Food Research Limited, 2011, 2013, 2014, 2015). Of these 560 foods, 56% were new food entries, and the remaining 44% of foods were replacements for results that were analysed >10 years ago, or food values borrowed from other sources. Fifty-five percent of the FCD were derived from a New Zealand analytical programme; 41% were derived by calculation (recipe or aggregation), usually from the analytical data; and only 4% were borrowed from other sources in 2012. The majority of borrowed data are for imported foods such as sesame oil, herbs, poppy seeds, cashew nuts, and kidney beans that are not produced in New Zealand.

The programmes of the last two years calendar years (2015 and 2016) will result in an additional ~190 food records being added to the NZFCDB. In terms of the number of new foods compared with replacement of older records, the trend is similar to that in 2011–14, with 57% of foods being new and 43% being replacement data (reanalysis of older foods and replacing data borrowed from other FCDBs). Most notably, the proportion of FCD derived by analysis will increase from 55% to 76% and the proportion derived by calculation (recipe or aggregation) will reduce from 41% to 24%. There will be no borrowed data for these foods.

NZFCDB international interactions

FAO/INFOODS

Suba Sivakumaran (PFR) is an international panel member for "FAO/INFOODS evaluation framework and criteria on the quality of published food composition tables and databases".

Siva Sivakumaran (PFR) completed the 12th International Postgraduate Course on the Production and Use of Food Composition Data in Nutrition - 13–25 October 2013 - Division of Human Nutrition of Wageningen University & Graduate School VLAG the Netherlands.

USDA Nutrient Data Laboratory (NDL)

Food composition data for New Zealand kiwifruit *Actinidia chinensis var. chinensis* 'Zesy002' (Zespri® SunGold Kiwifruit, commonly known as Gold3) was published by the USDA Nutrient Data Laboratory (NDL) https://ndb.nal.usda.gov/ndb/foods/show/2470?manu=&fgcd=&ds=. This Food Record is also found in the current NZFCD product New Zealand FOODfiles 2014 Version 01 on the website www.foodcomposition.co.nz.

11th International Food Data Conference "Food Composition Data and Public Health Nutrition" 3–5 November 2015

The 11th International Food Data Conference on Food Composition and Public Health Nutrition was held at the National Institute of Nutrition, Hyderabad, India, on 3–5 November 2015. Over 300 delegates from 37 countries attended the conference (Sivakumaran & Sivakumaran, 2015).

Suba Sivakumaran and Siva Sivakumaran attended the conference, presenting two papers (Sivakumaran et al 2015a, Sivakumaran et al 2015b) which have subsequently been accepted for publication.

INFOODS Success Story Award 2015

The NZFCD has been recognized internationally by winning an INFOODS Success Story Award 2015. This award recognizes the significant achievements of individuals or groups in the implementation of food composition activities, and was presented to Siva Sivakumaran and Suba Sivakumaran at the 11th International Food Data Conference, Hyderabad, India, in November 2015.

Food–Health relationship Database

The Food-Health Relationship Database (formally known as Biomarkers Database) was developed in 2014 to inform health claims. It includes data on foods, food components, health/physical states and biomarkers thereof, and is underpinned by peer-reviewed scientific and clinical literatures. Its development was guided by an advisory panel consisting of New Zealand food and regulatory representatives. Currently, it exists as a working prototype with a base dataset of 100 biomarkers and associated food and health data. It uses data directly from NZFCDB (FOODfiles 2014 V01). Its key value is in the identification of validated links between food and health. Funding (FRIENZ - Facilitating Research and Innovation co-operation between Europe and New Zealand) was received from MBIE (Ministry of Business, Innovation and Employment) to further develop this database, and the related Food Composition Database, in partnership with European agencies and New Zealand.

Carolyn Lister (PFR) presented "Supporting food health claims in New Zealand's regulatory environment" at the BACCHUS 'Best practice in health claims' Workshop, Brussels, Belgium, on 10 June 2016 (http://bacchus-fp7.eu/best-practice-in-health-claims-bacchus-workshop/).

In conjunction with this programme, a poster on "Comparison of three methods for total vitamin C analysis for Zespri® SunGold Kiwifruit, *Actinidia chinensis var. chinensis*" by Sivakumaran, Sivakumaran, Huffman, McGhie & Drummond (2016) was displayed at the EuroFIR Food Symposium on 6 April 2016.

EuroFIR FoodEXplorer

Europe is one of New Zealand's biggest export markets and there is demand for New Zealand food composition data. Following a request from European Food Information Resource (EuroFIR), we have given permission for FOODfiles 2014 V01 to be included in EuroFIR's web tool, FoodEXplorer. FoodEXplorer provides harmonized and standardized food information from 28 national food composition databases (www.eurofir.org/food-information-new/). PFR gained EuroFIR membership in 2015/16.

New Zealand–Australia food composition meetings

Key organizations from New Zealand with food composition related activities (including PFR, MoH and Ministry of Primary Industries (MPI)) meet with Food Standards Australia and New Zealand (FSANZ) by video conference approximately every six months. During these meeting both countries share information about recent analyses and discuss technical issues.

Future works

PFR has initiated a replacement of NZFCDB interface system. The new interface will improve the ease of maintenance and use, stability, and provide opportunities for significant expansion of functionality for users. Two approaches being considered: a) re-development of NZFCDB replacing FIMS and the FCDB Auxiliary with a single new application, and b) transition to the use of FoodCASE application available from Premotec GmbH. FoodCASE was originally developed at ETH Zurich, Swiss University (Presser et al. 2017).

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Country Report - Papua New Guinea

Lazarus Dawa, Technical Officer, Public Health Nutrition, National Department of Health

Background

Papua New Guinea (PNG) has a population of approximately 8 million people, with most (87%) living in rural areas and 40% under the age of 15 years. Total land area is 462 840 km^2. The capital city is Port Moresby. PNG gained independence from Australia in 1975. PNG is a culturally and geographically diverse nation with more than 800 languages spoken.

Malnutrition, especially undernutrition including stunting and vitamin A deficiencies, is of moderate to high prevalence in PNG according to the National Nutrition Survey (2005) and Household Income and Expenditure Survey (2009-2010). While some areas lack access to sufficient nutritious food, in other areas an abundance of food leads to problems. Government policies aim to address food quality, quantity and safety.

Nutrition and food supply issues in PNG

Three key indicators of undernutrition in PNG are the rate of low birth weight of infants, childhood stunting and underweight, and anaemia prevalence. There has been a slight decline in low birth weight babies over 4 years, with a low birth rate of 9% in 2012 compared to 10% in 2008 (NHIS, 2013). Stunting rates in children up to 59 months of age are as high as 48%, with the rate of underweight being 27%. Anaemia remains a significant public health concern. Prevalence is higher in children <60 months (~48%) and women (~36%) than in men (~26%), highest in the Momase region and lowest in the Highlands (see Figure 1) (PNG National Nutrition Survey, 2005).

The WHO recommends that infants are exclusively breast fed if at all possible and that complementary foods are not introduced before the age of 6 months (WHO, 2003). It was found that while almost 80% of infants are breast fed at 0-1 month, only 35.6% of babies receive breast milk only at the age of 4-5 months. Mixed feeding starts as early as 0 months (17%) to 5 months (57%). The main foods given before 4 months are solid mushy food (27%), plain water (10%) and dairy milk (7.8%) (DHS, 2006).

Problems of over-nutrition are also evident in PNG. Current WHO (WHO, 2014) estimates indicate 16% of adults are obese and non-communicable diseases are responsible for almost half of all deaths. The probability of dying from one of the four main non-communicable diseases (diabetes, cardiovascular disease, cancer or respiratory disease) between the ages of 20-70 years is 26% (WHO, 2014).

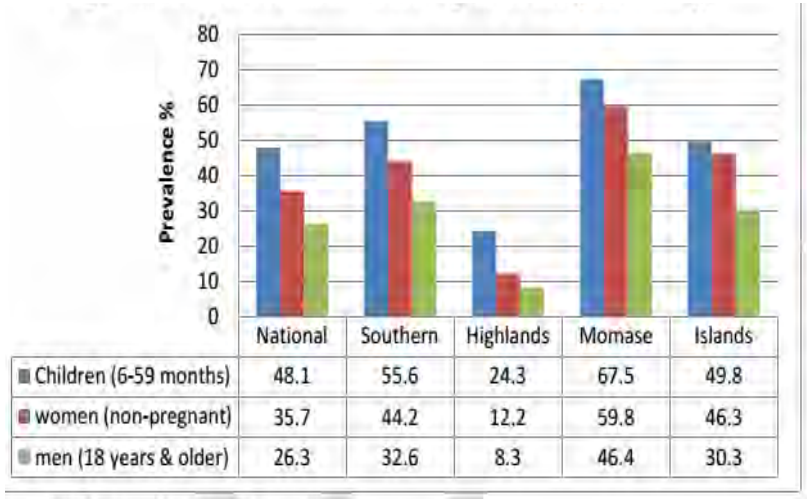

Figure 1: Anaemia prevalence in regions of PNG (PNG National Nutrition Survey 2005)

Note: anaemia defined as being Hb<11.0 g/dL in children, Hb<12.0 g/dL in women, and Hb<13.0 g/dL in men (Hb adjusted for altitude and cigarette smoking)

Local staple food makes up 68% of total energy intake of a person in PNG. Food imports amount to 10% of total imports and most people eat locally produced foods including fish, meat and garden foods (Bourke & Harwood, 2009).

In order to address nutrient deficiency diseases, some manufactured foods are fortified. Voluntary fortification is allowed for noodles (with B vitamins) and margarine (vitamin A). There is mandatory fortification of white rice with iron, thiamin and niacin, and of salt with iodine. Fortification of wheat flour with iron, folic acid and zinc is proposed. Wheat and rice imports are increasing every year, thus food fortification provide an avenue to bring micronutrients to the population that needs them.

To address the range of nutrient and food supply problems, Government policies on food security and safety, nutrition, and water and sanitation aim to:

» Increase food production (especially protein source and fruits/vegetables)

» Increase food access to all populations

» Ensure safe food, hygiene and sanitation

» Prevent diseases and infections

» Promote healthy lifestyles.

The PNG Government's vision for 2050 is for a *Smart, Wise, Fair, Healthy and Happy Society* (PNG Government, 2011).

Food composition activities in PNG

Food composition activities are limited in PNG at present. National food composition tables do not exist. For activities such as estimating nutrient intakes in national nutrition surveys, the South Pacific Food Composition tables are used. Current government policies do not extend to support for generating new, PNG-specific food composition data.

Government laboratories in PNG are mainly used for student research and industry testing and include:

» National Analysis Laboratory (soil and mineral, water testing)

» National Agricultural Research Institute (NARI) chemistry laboratory (water and food testing)

» UNITECH laboratory (food and microbiology)

» SMHS micronutrient laboratory (micronutrient and biochemical tests).

Planned surveys include:

» DHS 2016 – Data on child health, nutrition, infant and young child feeding (IYCF) and food fortification

» STEPS Survey 2017 – Data on risk factors for NCD, food consumption, food fortification including salt.

» National Nutrition Survey (potentially)

» Other research, including a situational analysis on food monitoring at the port of entry to PNG (PNG Customs Service and others) and a flour fortification study (UNSW).

There are many challenges for food composition surveys in PNG including high logistic costs, lack of government commitment and lack of technical expertise and laboratory facilities.

Conclusions

There are many challenges facing PNG that are relevant to food composition. Addressing malnutrition requires consumption of quality wholesome local foods. It is important to understand that food and micronutrient supplements are unsustainable and undermine quality of local foods. Therefore diet diversity promotion must be substantiated with food composition data.

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Are your data up to standard? Traceability and uncertainty of measurement results

Emeritus Professor D Brynn Hibbert,
School of Chemistry, University of NSW

Whenever a food is chemically analysed whether to obtain nutritional information, for regulatory purposes, or for label claims, it cannot be taken for granted that the results are correct, or fit for purpose. Since the advent of ISO/IEC 17025:2005 (ISO/IEC, 2005) (also adopted as an Australian Standard) *measurement results*[4] (JCGM, 2012) should have an estimate of *measurement uncertainty* and must be metrologically traceable to an appropriate reference. However it was only in 2011 that *metrological traceability* was put on a sound theoretical footing for measurement results in chemistry (De Bièvre, Dybkaer, Fajgelj & Hibbert, 2011). The present paper will describe the requirements for metrological traceability and give some practical advice for food chemists.

Metrological traceability

The definition of metrological traceability [VIM 2.41] is:

"..property of a **measurement results** whereby the result can be related to a reference through a documented unbroken chain of **calibrations**, each contributing to the **measurement uncertainty**".

The rationale for *metrological traceability* is the need for *metrological comparability* of measurement results. This is the concept that any *measurement* is made to compare the result with another value, for example a regulation threshold, an intended value, or a value obtained on a previous occasion. Just as it is often said that "apples cannot be compared with oranges", perhaps philosophically hard to justify, in metrological terms two *quantity values* cannot be compared if they are in different *units*, or traceable to different references. The definition of metrological traceability tells us that given a reference, the way we trace to it is through *calibration*. A clear example of an 'unbroken chain of calibrations' is given by measurements of mass. How is a kilo of potatoes bought at a local store 'metrologically traceable' and what is it traceable to? In Australia the SI (Système international d'unités or International system of units) (BIPM, 2006) has been adopted at the legal system of units, and so masses should be traceable to the kilogram. At the time of writing[5] the kilogram is defined as the mass of the international prototype of the kilogram, an artefact housed at the BIPM in Paris, and colloquially known as the 'Big K'. Therefore the scales at the store checkout will be periodically calibrated by a standard weight, its mass being traceable, perhaps through two or more artefacts, to the Australian kilogram (held at the NMI in Sydney). The Australian kilogram is occasionally taken

4. In this paper a metrological term that is defined in the VIM [2] is in *italic* font the first time it appears.
5. It is likely that the 'new SI' will define the kilogram in terms of a fixed value of the Planck constant, or a fixed value of the mass of ^{12}C.

to Paris and weighed by a glorified balance, called a mass comparator, against one of the six copies of the international prototype. They in turn have been compared with the 'Big K' twice since 1900. Having an international system means that mass measurements made anywhere in the world that subscribe to the SI are comparable being 'traceable to the same reference'. The second part of the definition 'each contributing to the measurement uncertainty' indicates that at each level of calibration when a measurement is made there must be an addition to the overall measurement uncertainty. When a standard weight is used to calibrate, for example the store scales, it comes with a certificate detailing its measurement uncertainty, and this uncertainty is combined with the measurement uncertainty of using the store scales to give an estimate of measurement uncertainty for the mass of the potatoes. As we go higher in the *calibration hierarchy* the measurement uncertainty of each stage tends to be smaller, with properties of *certified reference materials* (CRM) being more carefully measured than those of routine samples (hence the cost of CRMs).

Metrological traceability in chemistry

We have seen mass measurements have a straightforward, if perhaps long, *traceability chain* to the SI kilogram. However chemists also make measurements of amount of substance in the *SI base unit* mole (abbreviated mol). Chemists should not need reminding of the definition of the mole, but in a recent review to the CCQM the author noted that not one of 18 contemporary first year undergraduate text books correctly defined the mole, and many failed to mention the *kind-of-quantity* amount of substance.

1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.
2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

So the mole is not an Avogadro Number of things, it is an amount of substance; indeed only the Avogadro Constant is recognized in the SI (with unit mol-1). The problem with chemistry, therefore, is that because of the second clause, there are an infinite number of moles, with no 'Big Mole' sitting in a vault in Paris or anywhere. Chemists trace to the mole by our knowledge of atomic and molecular weights, and then through masses and volumes. Consider the calibration of a GC-MS for the analysis of residues of the pesticide dieldrin. A pure CRM is purchased with its certificate of purity, for example from NIST in a 13 compound pesticide residue in hexane reference material: (https://www-s.nist.gov/srmors/certificates/2261.pdf). In this example the certificate gives the mass fraction of dieldrin as 3.012 ± 0.020 mg/kg and its mass concentration 1.972 ± 0.013 µg/mL. A two-point calibration bracketing the concentration of the test sample requires the weighing of aliquots of the standard solution and addition of a known mass (or volume) of pure solvent to achieve the required concentration for the GC analysis. If amount of substance is needed then the masses are divided by the appropriate molecular weight. In general the amount of substance concentration in a standard, prepared from a 'pure' sample containing substance 'A' is

$$c_{\mathrm{A}} = \frac{w_{\mathrm{A}} m_{\mathrm{A}}}{M_{\mathrm{A}} V}$$

where A is the mass fraction of A (purity) in the standard in kg/kg, and M_A is the molar mass of A in kg/mol.

With traceable weights and volumes (including the volume injected onto the column) the measurement of the test sample solution is now traceable to the references stated on the various certificates, hopefully to the SI units mol, kg, and m (m^3 for volume).

The cost of CRMs (which, if used for calibration, should not also be used as a trueness control because of the circularity introduced) often dictates that a laboratory will use the precious CRM to obtain the concentration of a larger amount of in-house calibration standard. The in-house material is then used for routine calibrations. The uncertainty of the value associated with the test sample is increased by the uncertainty of this extra calibration, but if carefully done (e.g. with more replicates than for a routine sample) this need not have too great an effect on the final result.

Not all measurements are made in SI units. Many medical and biological measurement results are in conventional units, such as 'international units' which relate to pharmacological activity. Note that the definition of metrological traceability says 'reference' with no mention of the SI. Therefore all measurements are traceable to something, even if it is to the purity of an old bottle of chemicals on the laboratory shelf. See De Bièvre et al. (2011) for examples of metrological traceability chains in chemistry, including pH, and protein in grain.

Measurement uncertainty

Since the publication of the first Guide to the Expression of Uncertainty of Measurement, the so-called GUM, (Joint Committee for Guides in Metrology, 2008) the measurement community has had a description of how to obtain measurement results with appropriate measurement uncertainty. It is true that the mathematical rigour and 'bottom up' approach of the GUM has not excited practical chemists and food scientists, but there is a growing realization that measurement uncertainty is important and must be estimated for any measurement. The 2008 edition is now under revision by the Joint Committee for Guides in Metrology (Bich et al. 2012), with the first draft being universally condemned as almost unintelligible and of no use to chemists[6] . The document prepared by CITAC/EURACHEM (2012), which is compatible with the present GUM, has been better received.

Steps in estimating measurement uncertainty are

1. Define the *measurand*
2. Identify uncertainty sources – group where possible
3. Quantify uncertainty sources
4. Combine uncertainties (Law of propagation of errors …)
5. Apply a coverage factor
6. Report uncertainty with probability range with appropriate significant figures.

One outcome of the GUM approach is to cause scientists to think about their measurement

6. The author is a recently-retired member of the committee responsible for the GUM, and would argue there has been a misunderstanding of the role of the GUM, which is as the top standard, not a user-friendly manual. However there is an attempt to make the new edition accessible to a wider readership.

('define the measurand' – what is actually being measured?), and by looking at individual sources of uncertainty makes it easier to identify where improvements can be made to reduce overall measurement uncertainty. The GUM concept of determining the distribution of the measurement result (Bich, Cox, & Harris, 2006) leads naturally to quoting either the *standard uncertainty* (*u*, one standard deviation of the distribution) or the *expanded uncertainty* (*U*, an interval covering a given fraction of the distribution, for example a 95% coverage interval). A recommended form of expressing a result is thus "The mass fraction of sodium in food xxx = (11 ± 3) mg/g where the number following the symbol ± is the numerical value of an interval estimated to have a level of confidence of 95 percent". If nothing else adherence to the GUM will ensure having the proper number of significant figures.

Conclusions

This paper has highlighted the need for metrological comparability of measurement results, which is met by establishing their metrological traceability to a common metrological reference (SI or non-SI). To obtain an 'unbroken chain of calibrations' calibration standards should be certified reference materials (the certificate giving details of the property's traceability and uncertainty) or in-house standards measured against a purchased CRM. Finally measurement uncertainty should be assessed by a method consistent with the GUM, and reported in a proper format.

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Analytical Data Quality Assessment: Development of Reference Materials

Paul Armishaw, Manager Chemical Reference Values,
National Measurement Institute, North Ryde, Sydney, Australia

This paper describes the important aspects of analytical measurement and the production and use of reference materials for ensuring analytical quality.

Metrological comparability of measurement results

Metrological comparability of measurement results is "comparability of measurement results, for quantities of a given kind, which are metrologically traceable to the same reference." (BIPM 2012).

Metrological traceability is a "property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty" (BIPM 2012). Metrological traceability underpins comparability, and means measurements can be meaningfully compared, even when made at different times, at different places, by different people and using different equipment.

For metrological comparability, measurement results need to be traceable to a common and agreed reference. This may be the appropriate SI unit: mole, kilogram, metre, ampere, second, kelvin, candela. Or it may be a standard method for defined measurands, e.g. total fibre in food, or an artifact such as a reference material.

Reference Materials (RM) and Certified Reference Materials (CRM)

A reference material can be defined as material, sufficiently homogeneous and stable with respect to one or more specified properties, which has been established to be fit for its intended use in a measurement procedure (International Standards Organization (ISO), Guide 30).

Table 1. Component of selected components in SRM 2387

Component	Value	Units
Ash	3.10	g/100 g
Calories	629	kcal/100 g
Carbohydrates	25.0	g/100 g
Dietary Fiber-Total	5.57	g/100 g
Fat (extracted)	51.6	g/100 g
Protein	22.2	g/100 g
Solids	99.2	g/100 g
Sum of Fatty Acids (as triglycerides)	49.8	g/100 g

https://www-s.nist.gov/srmors/view_detail.cfm?srm=2387

A certified reference material is defined as reference material characterized by a metrologically valid procedure for one or more specified properties, accompanied by an RM certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability (ISO Guide 30). Reference materials contain detailed information on the composition of the material. For example Table 1 (left) shows the composition of a reference material (Peanut butter, NIST SRM 2387).

There are a number of standards available for reference material producers. They including:

» ISO guide 34: General requirements for the competence of reference material producers
» ISO Guide 35: Reference materials – General and statistical principles for certification
» ISO Guide 31: Reference materials – Contents of certificates, labels and accompanying documentation
» ISO Guide 30: Terms and definitions used in connection with reference materials
» ISO Guide 32: Calibration in analytical chemistry and uses of certified reference materials (withdrawn 2015).

The National Measurement Institute (NMI) has the capability to make high-accuracy, traceable reference measurements. These reference measurement procedures are used to characterize certified reference materials and proficiency testing samples. This process is outlined in Figure 1.

Certified reference materials have to conform to certain criteria such as:

» property values which are metrologically traceable
» being stable during storage and transportation
» homogeneous between units and within units (with minimum sub-sample specified)
» available in a useful form - pure solid, solution, freeze dried etc.

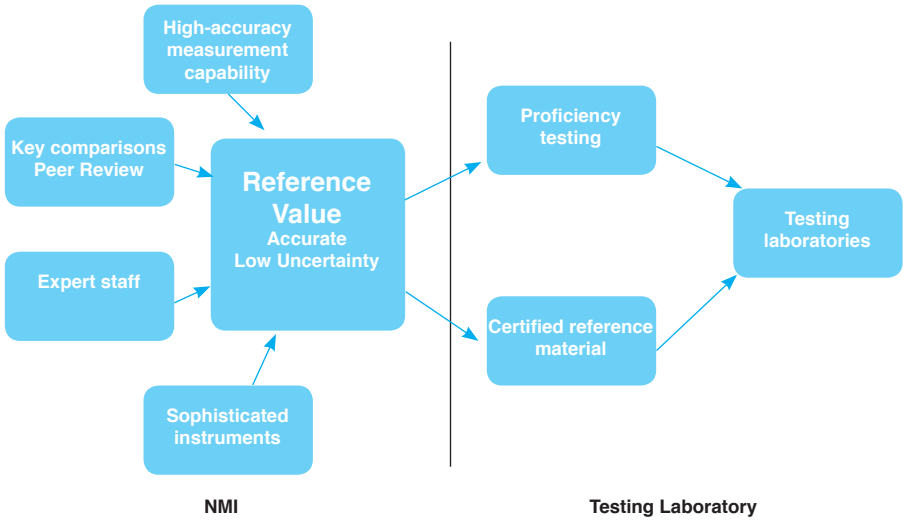

Figure 1: Production and dissemination of reference materials by NMI

A certificate of a reference material should include some key elements to provide the user with necessary information to properly use the material and assess their measurement results. ISO Guide 31 suggests the following contents for certificates:

» Title of document
» Name of material
» Reference material code and batch no.
» Description of the CRM
» Intended use
» Instruction for use and storage
» Safety information
» Property value, measurement uncertainty (MU), certification method
» Date of certification
» Traceability and period of validity
» Other relevant information.

It is crucial where possible to use a reference material that with a similar matrix to the sample being measured. However a suitable reference material is not always available.

Where laboratories cannot source a suitable reference material, in-house materials can be produced by the respective laboratories. ISO Guide 80 specifies the procedure for preparation of such materials.

Method validation demonstrates that the performance properties of a measurement method are within specification, and the method is fit for purpose. Reference materials are valuable tools for use in the validation of chemical test methods. The key performance properties are

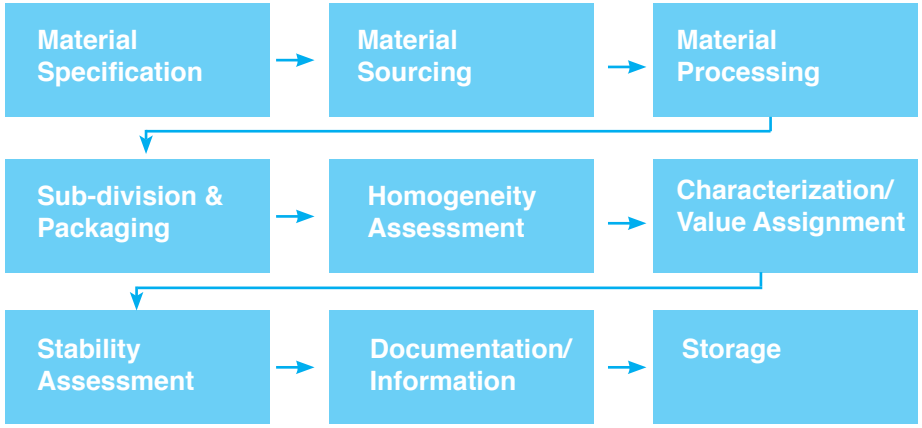

Figure 2. ISO Guide 80 - Guidance for the in-house preparation of quality control materials (QCMs)

selectivity, recovery, bias, robustness and trueness. The method performance criteria such as precision, measurement uncertainty (MU) and control chart limits are also useful for assessing measurement uncertainty and establishing traceability.

Once the method has been validated and is in use, matrix RMs are used to verify/demonstrate/provide objective evidence that the method is still performing as it was at time of validation.

Figure 3 below is a representation of the use of reference materials in an analytical method.

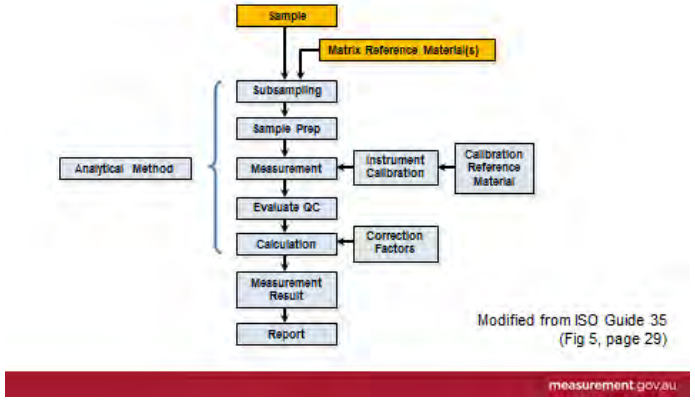

Figure 3: Use of reference materials in analysis

One role of reference materials is to verify method performance where it imitates a real sample and undergoes every step in the measurement procedure. The matrix reference material, when processed as a sample, will check:

- contamination control in sample handling
- digestion efficiency
- volatile losses
- cleanup
- matrix effects – ionisation suppression or enhancement – performance of internal standards
- matrix interferences (systematic error)
- overall method precision
- overall method accuracy
- calibration stability
- calibration accuracy.

Thus matrix reference materials are useful for both method validation as well as for ongoing Quality control.

Using matrix reference materials

The certificate provided to the user will only be valid if the user follows instructions on storage, use within expiry date, sample handling and continuous monitoring of moisture content.

Availability of reference materials

The laboratories can look up the COMAR database for certified reference materials, maintained by the German National Measurement Institute (BAM), that provides all reference materials available in the world including in Australia. The National Measurement Institute in Australia is the regional coding centre for Australia. The National Association of Testing Authorities (NATA) holds a list of all Australian laboratories accredited for certified reference material production. COMAR database holds a list of ~ 10,000 certified reference Materials (CRMs).

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Managing and Performing Analytical Programs to Ensure Quality Outcomes

Tim Stobaus, Laboratory Service and Food Residue Teams Manager, National Measurement Institute, Port Melbourne

What is the National Measurement Institute?

The National Measurement Institute (NMI) (www.measurement.gov.au) is part of the Australian Government's Department of Industry Innovation & Science and is Australia's peak measurement body responsible for biological, chemical, legal, physical and trade measurement. NMI has multiple functions carried out across four branches: Legal Metrology & Trade Measurement; Physical Metrology; Chemical and Biological Metrology; and Analytical Services.

The Analytical Services Branch (ASB) role is primarily to deliver fee-for-service analytical capabilities to meet the biological and chemical measurement needs for a range of stakeholders across government, industry and the wider community. The provision of a broad suite of evolving services enables ASB to maintain a relevant and current analytical capability for Australia e.g. for the purposes of food crisis response, while recovering a significant proportion of costs. Services range across the food, environment, resources and health sectors. ASB has a broad stakeholder base, with clients from government (local, state and federal), industry (agriculture, food processors and retailers, other laboratories), the tertiary education sector and the media. ASB is located in Perth, Melbourne and Sydney.

The Food Focus ("Food Sector") activities of ASB are largely located at our Port Melbourne laboratory. These activities include analyses for:

- nutritional and functional components
- food safety (chemical residues, metals, microbiology, allergens)
- food authenticity (including speciation, profiling and verifying claims)
- investigation of food and packaging quality and safety issues (chemical migration, taints, spoilage, organoleptic issues and foreign matter).

NMI's vision for the Food Sector is to deliver capability for food measurement in Australia that is world class, enhances export food trade prospects, empowers sound food regulation and assists in delivering food related social and health benefits to the community.

ASB uses a solution based approach (compliance, assurance, marketing, development). NMI is accredited by major national and international quality systems bodies and operates Quarantine Approved Premises[7].

7. Approved arrangements, previously Quarantine Approved Premises and Compliance Agreements, are voluntary arrangements entered into with the Australian Department of Agriculture and Water Resources. These arrangements allow operators to manage biosecurity risks in accordance with departmental requirements, using their own premises, facilities, equipment and people, and without constant supervision by the department and with occasional compliance monitoring or auditing (http://www.agriculture.gov.au/import/arrival/arrangements).

NMI Port Melbourne staff are largely science graduates (including Bachelor degrees with Honours, Masters and PhD qualifications) in chemical, microbiological, biochemical and food technology disciplines. The average age of ASB staff is 43 years and average professional experience is more than 10 years.

The Branch operates a number of tertiary education collaborations with a range of institutions including James Cook University, RMIT and Victoria University amongst others. These include advanced projects for post graduate students as well as student placements and work experience, from 2 weeks to 6 months, full and part time. Through these collaborations, students are assisted to develop new capabilities whilst benefitting from access to advanced analytical equipment and facilities. Many students are also often given the opportunity for paid part-time work.

Planning for large scale programs and surveys at NMI

A key driver for NMI's Food Sector activities is a requirement for major food metrology studies involving sophisticated and/or large volume testing requirements. Such studies arise from the needs of a range of clients/stakeholders (as outlined above) and serve a significant purpose, such as:

» dietary studies for nutrition or safety
» product shelf life monitoring
» inform regulation and enforcement
» supporting product marketing

Tertiary sector and government programs (such as the food composition studies commissioned by Food Standards Australia New Zealand (FSANZ)) tend to be more sophisticated in their requirements compared to "routine" submissions NMI where standard NMI protocols are applied. These studies may have a statistical basis for representative sampling and sample handling protocols and prescriptive protocols for all aspects of the program including:

» Handling, preparation and storage of samples
» Analytical methods to be applied and method performance
» Quality criteria to be met
» Reporting formats and presentation of data
» Requirements for QA information including traceability and measurement uncertainty.

Figure 1 outlines the flow of samples and data through the laboratory systems.

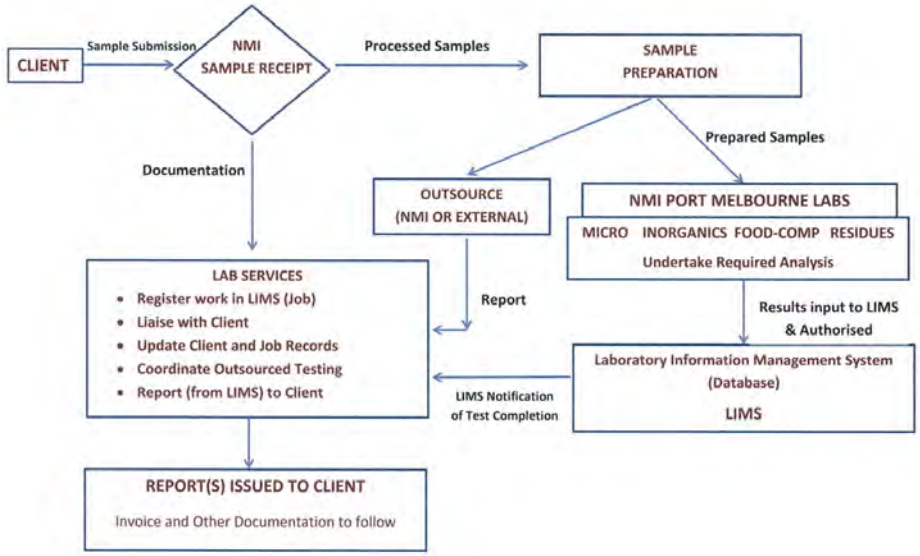

Figure 1: NMI Laboratory process flow diagram, from sample receipt to issue of reports to clients

When approached to tender for or undertake a program, NMI must consider a range of issues including:

» Is the program within the general ambit of NMI capability and logistical capacity?
» Are there important geographic, political, environmental, legal, safety and quarantine aspects not appropriate to NMI?
» Is method development and validation or verification required (e.g. low level of vitamin D in foods)?
» Q A and method performance requirements and accreditations
» Specific requirements around sampling, transport and preparation
» Reporting requirements.

NMI uses a collaborative approach to planning and implementation. Detailed negotiation and agreement on all aspects of program operation and delivery helps to ensure parties will be satisfied with outcomes and avoid missed expectations. Planning aspects considered include:

» agreed protocols
» agreed milestones for program delivery
» agreed quality and method performance
» appointment of an NMI program coordinator(s) and deputy
» project plan developed and communicated
» project staff meet with stakeholders
» dedicated project folder allocated on NMI network drive.

Conducting large scale analytical programs

There are many factors in achieving quality data, including food composition data. The primary factors NMI deals with are outlined in this section.

Sampling and transport

Representative sampling and maintenance of sample integrity in transit is critical to a meaningful program outcome. Sampling considerations include:

» geographic representation (shops, farms, factories)
» variety of brands, production/growing dates, shelf life, authentic articles
» composition of final samples for analysis (e.g. compositing a number of purchases).

Transport considerations are critical to maintaining sample integrity. These include consideration of transport temperature, sample protection and service delivery times, which are typically 24 hours within Australia, although this can be expensive.

At the laboratory, a quality systems approach is used. NMI and other major commercial laboratories place a strong emphasis on Quality Systems Accreditation and Good Laboratory Practice to help ensure quality analytical and service outcomes. Accreditation is often critical to credibility and client confidence. NMI is accredited, by the National Association of Testing Authorities (NATA), to the internationally recognized laboratory accreditation standard ISO 17025:2005 (http://www.iso.org/iso/catalogue_detail.htm?csnumber=39883), http://www.nata.com.au/nata/).

NATA is a member based organization which accredits lab facilities, and specific test methods they perform, to ISO 17025 standards. Laboratories may also be Systems Accredited, for example NMI maintains accreditation to ISO 9001:2008. Note that occupational health & safety is not directly covered under these Quality Systems.

ISO 17025 accreditation covers the total laboratory operation in terms of:

» Management systems and administrative processes
» Elements of service provision and customer management
» Elements of supplier approval and traceability of standard materials
» Equipment maintenance and calibration
» Records management
» Electronic systems e.g. laboratory information management systems (LIMS) and in-house applications such as Microsoft Excel or Access based systems with embedded macros.

Sample Processing - Integrity and Traceability

Identity and traceability is maintained by assigning a unique identity (Laboratory Registration Number or LRN) for each sample and sub-sample. A program “Job” is set-up in the NMI LIMS that includes these LRNs.

Storage arrangements cover a range of temperature options (-80°C, -20°C, 4°C, Ambient, Incubated). Space requirements can be significant for large scale programs, often requiring walk-in size refrigerators and freezers. It is important that sample items be stored in a highly systematic way to enable retrieval and help avoid any losses.

Records management for storage of sample information and results is critical. ASB uses a single location for electronic records (e.g. scanned items, photographs) and LIMS to store results of analyses. Excel workbooks are used for sample details that LIMS does not accommodate, such as information on purchase dates and locations, stores and preparation notes.

Sample Preparation

Representative and well-homogenized sample preparation is critical to the integrity of analysis. Important factors to consider in regard to ‘fit for purpose’ preparation include:

» matrix considerations
» sample homogeneity (especially for mixed component foods)
» quantity of sample available
» distribution of analyte in the matrix (e.g. aflatoxin in nuts which is quite heterogeneous and requires a very large sample size, over 20kg in some jurisdictions, to be statistically sub-sampled)
» physical characteristics of matrix (e.g. hardness, viscosity, sinew, pliability etc.).

Modes of sample preparation include blending (using a variety of blender types), cutting with knives (manually or mechanically) and grinding (using a variety of grinders and mortars). Sometimes, liquid nitrogen or pre-freezing, or pre-heating is used in preparation.

Figure 2 shows an example of a sample preparation protocol based on a survey of metals in canned fruits.

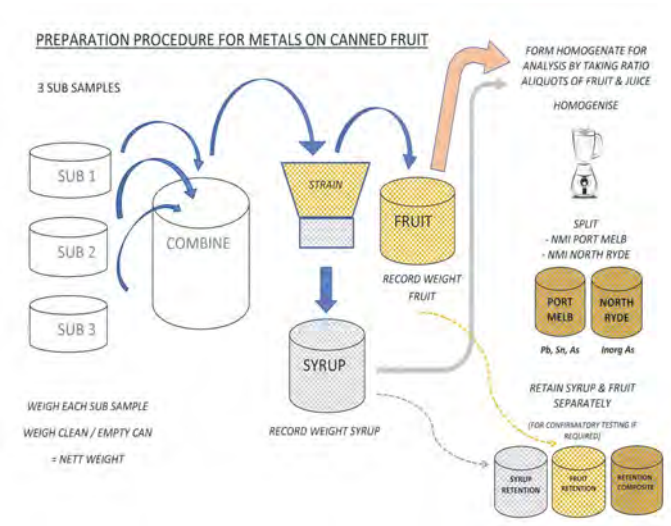

Figure 2: Example of a sample preparation protocol used at NMI for the analysis of metals in canned fruits.

Method selection

Method selection is critical to ensuring a meaningful study outcome. Matters to consider in this regard include:

» accreditation status of the method including application to the sample type
» validation/verification for the sample type
» international recognition of available tests (e.g. AOAC, AACC etc.)
» historically comparable results (enable comparison to previous studies, literature)
» equipment/instrument technology
» time, cost and quality
» statistical aspects
» precision and measurement uncertainty.

Analytical controls and quality assurance (QA)

Laboratories need to ensure that their testing is sound. Laboratory equipment, materials, processes and staff competencies must be monitored and maintained to ensure a sound testing outcome in compliance to quality criteria. At ASB, work is performed by trained staff and overseen/reviewed by the authorizing analyst(s). Equipment (instruments, volumetric apparatus, calibrated glassware, balances etc.) must be properly maintained and monitored to ensure performance and in calibration. Chemical standards must be checked to ensure they are within their expiry date and are traceable in accordance to ISO Guide 34 requirements (ISO, 2009).

At ASB, appropriate reference materials (Controls) and/or Recovery samples are included

in each analytical batch with outcomes checked for compliance and charted (Control Chart) against expectation. Duplicate analysis and blanks are also routinely incorporated as part of the analytical quality control regime for virtually all analyses.

Review and acceptance of analytical outcomes is predicated on a number of criteria and factors, including:

» Analytical quality criteria are met indicating satisfactory method performance.
» The Authorising Analyst is satisfied with the overall quality and veracity of the testing process.
» The results makes sense in context, for example the data are consistent with the sample/product type in question, based on historical data and publications, or on label information for presence of food additives or other compositional claims.
» The data compatible with other results (particularly for nutritional parameters).

Note that for large scale program work there will be some errors (analytical, transcription, preparatory etc.). It is important to keep an open mind and be vigilant and to get stakeholder feedback on progress reports, rather than waiting until the end of analysis.

Storing and reporting results

Accurate and efficient results handling is just as important as the analysis itself. There has been a strong trend over many years for laboratories to handle data electronically, however some testing is still recorded and reported manually on written reports and printouts.

Electronic results handling has the following advantages:

» instrument software is linked, via a local area network (LAN), to LIMS for direct result transfer
» requires electronic authorization step and spot check/review of LIMS afterwards
» overall is fast and efficient and helps avoid transcription errors
» LAN with a server provides back-up for instrument and records data.

Manual or paper based systems can be more flexible than rigid electronic systems, especially where interpretive comments are required. Manual systems remain useful for low volume / low frequency applications where setting up electronic processes is not warranted.

It is important to provide results data and addendum information in a useful, user-friendly format. The great majority of labs provide their results in both a formal, paper or PDF-based certificate format, and electronically, such as in a spreadsheet. Electronic provision of data may encompass data files generated from LIMS (e.g. Microsoft Excel or CSV files); transfer across secure web based applications e.g. electronic partner gateways; and direct stakeholder access to the LIMS with a secure external login (usually limited to the stakeholder's own data). Formal certificates provide official, unalterable record of results and are a reference in the event that the electronic record is altered. They may be used for evidentiary legal purposes and citations. Formal certificates are, however, usually not user friendly for reviewing and handling large sets of data.

Depending on how the LIMS system is configured, it can be difficult for a LIMS to cater for all relevant program information. Additional information is often provided in the form of spread sheets or other electronic files and photographs. Examples of additional information include sample purchasing information, sample labels, interpretive notes and instrument outputs.

QA reports and statements provide the stakeholder with a record of the QA outcomes for each analysis (by analytical batch) against stated or contractually agreed acceptance criteria. It is usually provided in the form of a formalized certificate or statement. A simple formal statement that all quality criteria were met in the course of analysis undertaken is sometimes provided in place of a comprehensive report.

Review of Program Findings

Once the stakeholder/ client has had opportunity to review findings in detail they will often submit queries for the laboratory to follow up. Such enquiries usually relate to matters such as:

» Obvious transcription or information/data handling errors e.g. sample details, unrealistic result data and submission errors
» Unexpected results e.g. may not be consistent to other studies or literature
» Requests for further information e.g. detections at trace levels between limit of detection (LOD) and
» Limit of reporting (LOR)/ Limit of quantitation (LOQ).

Laboratories understand this is going to happen and consider some level of re-testing and provision of more information as part of the service.

Conclusion

Careful, detailed management of laboratory systems, by trained scientists, is essential in order to achieve quality analytical outcomes. Laboratory accreditation is an important part of this process and the systems approach established in standards such as ISO 17025:2005 helps ensure the veracity of the full sample management, analysis and reporting process within the lab. For example NMI's Analytical Services Branch holds NATA (ISO 17025) accreditation across a broad suite of food and environmental related testing employing a diverse range of techniques.

The success of a major food analytical program is often dependent on establishing up front agreement between the laboratory performing the analytical work and the stakeholder for whom the program is to be performed.

In particular it is critical that the laboratory understand the stakeholder's requirements and purpose for the work. This helps enable identification of fit for purpose methods, sample handling and reporting protocols. It is also important that the stakeholder understand the limitations of the sampling and methods (e.g. measurement uncertainty (MU)) to be applied and what this means in terms of achieving the required program outcomes.

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How good is your laboratory for performing analysis?

Dr Hayfa Salman,
Australian Export Grain Innovation Centre (AEGIC)

Introduction

Australian Export Grains Innovation Centre's (AEGIC) Analytical Services Laboratory Sydney, North Ryde, is accredited by the National Australian Testing Authority (NATA) and by the International Laboratory Accreditation Cooperation (ILAC).

Although AEGIC was established in 2012, the Analytical Services Laboratory was previously owned by Bread Research Institute (BRI) (1947-2008) and by Grain Growers Limited (2008-2015). The Analytical Services Laboratory has maintained a strong history of leading standards in Research and Development and in grains and grain product testing. It has maintained its NATA accreditation since 1952.

AEGIC's principal purpose is supporting the trade and use of Australian grain across the world. Its vision is to enhance the international competitiveness and value of Australian grain through science, technology and innovation.

Analytical Services Laboratory's objective is to provide high quality analytical testing. One way to achieve this is by maintaining its NATA accreditation.

Accreditation

Accreditation is a means of determining, formally recognising and promoting the competence of facilities that perform specific testing.

To gain accreditation, facilities regularly undergo peer reviews and assessment. Facilities can be private or government owned, and can range in size from a one-person operation through to large multi-disciplinary organisations. Since accreditation is highly regarded both nationally and internationally as a reliable indicator of technical competence, use of the accreditation endorsement on reports tells clients that the facility has been assessed against high standard international practice. The criteria for determining a facility's competence is based on relevant international standards established by the International Standards Organization (ISO) (e.g. ISO/IEC 17025, ISO 15189, ISO/IEC 17020) and include: the qualifications, training and experience of staff; correct equipment that is properly calibrated and maintained; adequate quality assurance procedures; appropriate sampling practices, and so on.

Accreditation to ISO 17025 means the laboratory follows this standard not only to provide trusted services but also to develop a management system for quality, administrative and technical operations. The standard also outlines how policies, systems and procedures are documented and how these policies, systems and procedures are to be communicated and implemented by the laboratory personnel. This accreditation also has technical requirements which include:

regular audits of technical competence such as qualifications and training; staff experience; correct use of equipment including calibration and maintenance; adequate quality assurance procedures; plus, appropriate sampling practices, and so on.

How is a laboratory accredited?

The process of accrediting a lab has the following elements:

» Familiarisation with the accreditation criteria

When seeking accreditation, staff should familiarize themselves with the standard and accreditation criteria for the field of testing, or program relevant to their application. In Australia, the NATA website is the place to start.

» Application for accreditation

To gain accreditation, the applicant will be required to provide a copy of its quality manual and other management system and technical documentation.

» Advisory visit

An advisory visit is an informal review of facilities, which is often undertaken by a trained assessor. The objective is to examine the major non-technical elements of the system and identify any significant gaps in relation to the requirements.

» Assessment

When the facility considers itself ready for evaluation, the accreditation body, in consultation with the facility, organises a team of technical assessors to review the facility. The objective is to establish whether the facility reaches the standards required for accreditation. The assessment team consists of at least one lead assessor, who reviews the management system, and one or more specialist technical assessors (depending on the areas that must be covered), who review the technical competence of the laboratory and staff. The assessment team investigates the operation of the facility against the relevant ISO standard and reports its findings to the facility seeking accreditation. The assessment involves a thorough evaluation of all the elements of the facility's operation that contribute to the production of accurate and reliable data. These elements include: management system, staffing (including training and supervision), methods (including validation/verification), quality control, proficiency testing, equipment including calibration, recording and reporting of results, and the physical environment in which the activities are performed.

» Scope of accreditation

Accreditation is described by classes and subclasses of a test or activity. The extent of a facility's accreditation is known as its 'scope of accreditation', described in classes and subclasses of tests or activities.

» Granting accreditation

Accreditation is granted following the recommendation by the relevant Accreditation Advisory Committee conducted during assessment, if the facility has met all the requirements for accreditation. The facility is formally advised of the granting of the accreditation and issued with a certificate and the scope of accreditation.

Auditing

The objective of auditing is continuous improvement. Audits are a scheduled series of detailed examinations of all the elements of the facility's operation that contribute to the production of accurate and reliable data. Both external and internal audits include examining practical assessment, documents and records, procedures, products and processes covered by the quality management system.

Audit scope

The scope of each audit will cover the relevant sections of at least the following elements: Laboratory Quality Manual; ISO/IEC 17025; internal and external documents (for example: methods, instructions for use) and internal records.

Internal audit

ISO 17025 requires an organization to employ an ongoing program of internal audits. Internal auditing can be applied to all or part of the system and it serves three purposes:

1. To provide evidence to management that a quality system is being implemented as intended.
2. To identify problems and facilitate the corrective action required and to prevent reoccurrence.
3. To identify opportunities for continual improvements.

The internal audit should be conducted by a person who has good knowledge of the quality system and the facility. However, knowledge and familiarity of the system can form a risk to the accuracy of the audit. The auditor attitude should be non-blaming, positive, non-threatening, and objective. Preferably, an auditor should have completed relevant training provided by a recognised organization.

Internal quality audits should be conducted as a scheduled series of detailed examinations of procedures, products and processes covered by the quality management system. Internal audits may also be conducted in response to a specific breakdown or potential problems in the quality system. Such audits will focus on identifying the root causes of the breakdown.

The schedule for the internal audits and the allocation of auditors will be prepared by the Quality Manager in consultation with the Laboratory Manager. Care should be taken to avoid self-auditing and the schedule should aim to cover all elements of the system in a 12-month period.

The outcomes of the audit should be discussed with relevant staff and at laboratory meetings. The results should also be discussed at regular management review meetings.

Responsibilities of the auditors

Besides performing the audits, the auditors are responsible for collating the relevant documentation prior to the audits, preparing the audit checklist and liaising with the auditees regarding timing of the audit.

Check list

Staff competence and training

Up-to-date staff training and competence records should contain information on the initial training and subsequent monitoring of staff.

Quality control

This includes assessment of internal and external quality control measures such as proficiency tests, internal check samples and batch check samples.

Methods

The availability of methods to staff, current version of the method in use, how it is understood by staff, and the measured uncertainty of the methods, are all generic items of methods auditing.

Equipment maintenance

The auditor should make sure that equipment is calibrated and fit for use. Calibration and performance checks should be traceable and performed at the appropriate frequency. All equipment should be uniquely identified and inventory and records of servicing and breakdowns/faults are kept.

Sample management

Facilities should have procedures for identification and recording results of samples received. Staff should be competent in the correct procedures for handling and preservation of samples.

Safety

Staff should be aware of hazards, specifically, MSDSs should be available and understood and ensure waste disposal is safe and environmentally sound.

Complaints, non-conformities, corrective and preventative actions

Records of complaints and corrective actions should be checked for validity. Root causes should be identified and records of actions taken completed.

Facilities and environment

Housekeeping standards should be adequate. Conditions of work should be fit-for-purpose.

Audit of the internal audits

All audits are performed and documented as per schedule and check list.

External auditing

External auditing is conducted regularly by the accrediting authority to ensure that the facility continues to meet accreditation requirements.

In addition to auditing laboratory operations, the external auditor will review the internal audit program and will assess the conduct and the findings during their audit of the facility.

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Food Composition Data Quality: EuroFIR Harmonization Approach

Dr Isabel Castanheira, Principal Scientist, Instituto Nacional de Saúde Dr. Ricardo Jorge (INSA), Portugal

Abstract

The European Food Information Resource (EUROFIR) is a network of national Food Composition Databank (nFCDB) compilers that aims to develop, manage and publish food composition data and to promote international cooperation and harmonization through improved data quality, database search ability and standards. The aim of this paper is to report the role of metrology and other quality tools in development of a quality evaluation system for analytical values from the scientific literature, laboratory reports or other data sources in a standardized way across Europe for nFCDB. Seven categories were used to score analytical data: food description; component identification; sampling plan; number of analytical samples; sample handling; analytical methodology; analytical quality control. The two most important metrological tools for improving the quality of data in nFCDB proved to be the use of SI units in modes of expression and the use of reference materials in laboratory analyses. A series of consensus meetings between national compilers, analysts, quality managers and metrologists developed and defined the overall data quality evaluation system (DQES). Consultations with key users and stakeholders across Europe helped to shape and refine quality requirements.

Introduction

The European Food Information Resource (EUROFIR) is a network of National Food Composition Databank (nFCDB) compilers that aims to develop, manage and publish food composition data and to promote international cooperation and harmonization through improved data quality, database search ability and standards (Westenbrink, Roe, Oseredczuk, Castanheira, & Finglas, 2016). One of EuroFIR's main objectives is the development of an integrated food information platform that provides single-point access to the various national authoritative sources of food composition data in each EU Member State, both for nutrients and for newly emerging non-nutrient bioactive compounds with putative health benefits (Unwin et al., 2016). EuroFIR has developed a series of activities to improve communication between producers of analytical data, national database compilers, stakeholders and users and has established a leading role in global harmonization initiatives for food information systems and data developing strong strategic links to various international bodies (such as INFOODS, IMEKO, USDA and FDA) in order to harmonize food description and data quality (Finglas, Berry, & Astley, 2014, and Finglas, Weichselbaum, & Buttriss, 2010).

Role of Metrology

Metrology, the science of measurement, plays an important role in EuroFIR's platform concept. The design includes traceability to SI units of nutrient and non-nutrient bioactive compounds with putative health effects (Castanheira et al., 2007). This paper presents the quality framework, and metrological approaches applied within EuroFIR to harmonize data interchange and improve the rigour of measurement processes when nFCDB are used to calculate and compare intakes of nutrient and bioactive components based on different national food composition datasets. The aim of the work was to study the role of metrology and other quality tools in harmonization of national food composition databanks.

Criteria defined in EuroFIR guidelines were used to define metrological critical points. The principles were based on the framework of ISO standards 9001, 17025 and 17024 that cover requirements for quality management systems and certification. These standards describe the requirements that a quality system should meet, but not how those requirements should be met, and therefore are flexible.

Outcomes

The first task was focused on the implementation of a quality framework in food composition database organizations, with emphasis on quality of laboratory analytical work and on data quality assessment. To assure the accuracy of analytical values and identification of artificial differences, a quality management framework has been agreed, including metrological requirements for description of foods, components and values, as shown in Figure 1. A critical analysis among existing food composition data banks currently available identified several parameters when data interchange or data management was needed by compilers or users such as researchers, regulators and industry. These parameters are depicted in Figure 1 below (Deharveng, Charrondière, Slimani, Southgate, & Riboli, 1999). They include mode of expression for vitamins; food description for carbohydrate foods and for fats; food sampling of representative samples; methods of analysis where different approaches were used, e.g. for vitamin B; and limits of detection (LOD) for trace elements. Miscoding due to different tagnames or misidentification of fat components had been detected (Slimani et al., 2007). Therefore, metrological principles such as traceability to SI units and the use of Certified Reference Materials (CRM) and participation in Proficiency Testing Schemes (PT Schemes) were the main recommendations for laboratories. For compilers a voluntary certification program was recommended in order to guarantee harmonized procedures. These would be the pillars to standardized food composition data banks in Europe. The intention was to create an interchange model able to guarantee comparability of databank structures that support food composition databanks available in Europe.

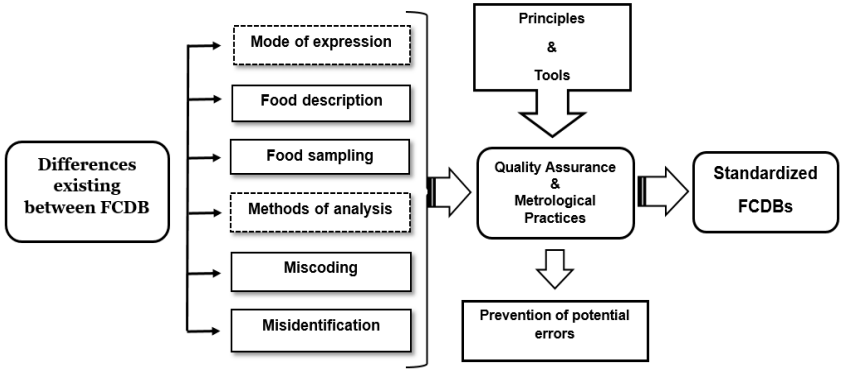

Figure 1: Quality strategies applied to harmonize food composition databanks. Dashed line rectangles indicate metrological intervention

At laboratory level, producers of analytical data were requested to implement a quality system in compliance with ISO/IEC 17025. The elements providing an indication of analytical reliability are:

1. Validated methods
2. Robust sampling practices
3. Proven calibration approaches
4. Natural matrix reference materials
5. Assessment of measurement uncertainty and establishment of traceability links to basic SI units
6. Participation in proficiency testing schemes.

EuroFIR was the first international organization to delineate these requirements for analytical processes which are revealed as crucial to guaranteeing the linkage of the overall measurement process adopted in the food composition arena (Figure 2).

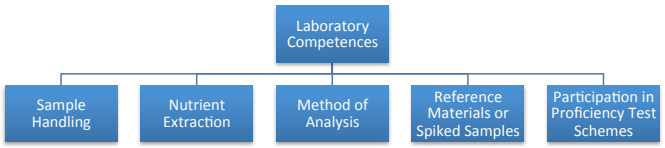

Figure 2: Required laboratory competences to generate reliable analytical data for food composition tables

The second task in the harmonization exercise was to address the compilation process, the next important step in production of food composition data. The internationally recognized and recommended systematic approach to the identification, evaluation and control of significant hazards, Hazard Analysis Critical Control Points (HACCP), was used as a starting point. All steps in the compilation process were listed and presented as a generic EuroFIR flowchart describing the overall food data compilation process and identifying hazards and critical control points. The flowchart and standard operating procedures, documenting how to control hazards at critical control points, are considered essential elements of the EuroFIR quality framework (Westenbrink, Oseredczuk, Castanheira, & Roe, 2009).

Because food composition data are supported by analytical values that generate single or aggregate values we studied the impact of harmonization to SI units in all values (nutrients and matrix) from analysis through to the compilation process. For the compilation process a set of standard vocabularies (thesauri) were defined to overcome previous problems in earlier attempts to harmonize the interchange of data at international level (Møller et al., 2008). SI units were adopted as the unique system for expression of numeric information in nFCDB, and as a consequence, two sets of standard vocabulary were defined. The Unit thesaurus contains terms for the measure used for the amount of the component value (nutrient or bioactive compound) or measurable property reported as the value. The Matrix Unit (Modes of expression) thesaurus contains terms for the amount of the matrix material (food) that has quantity reported as the value, usually expressed using the preposition 'per', e.g. per 100 g weight, per kg weight.

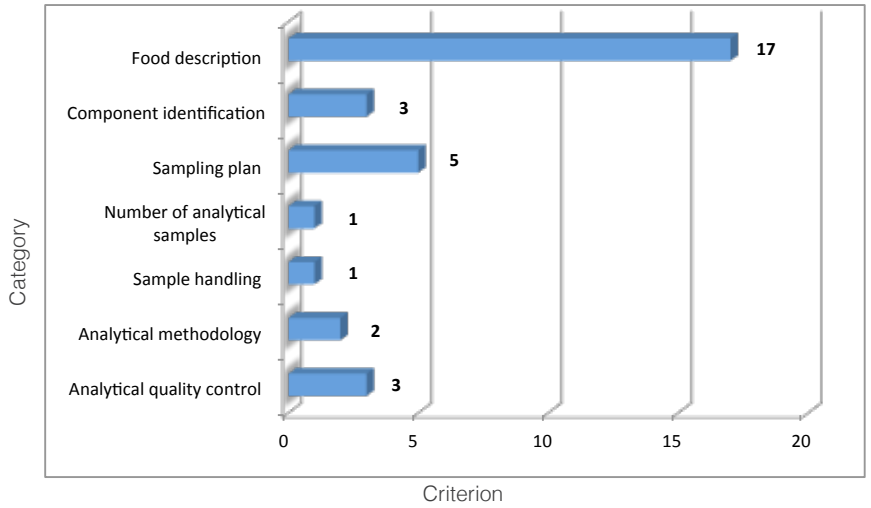

Figure 3. Quality Evaluation System as developed by EuroFIR to score analytical data

To determine and compare the quality of nutrient values within datasets, systems for assessment of their documentation have been developed. The quality assessment scales developed are currently limited to application to the scientific literature and include seven categories; food description, sampling protocol, number of samples analyzed, sample handling, analytical method, execution of the analytical method by the laboratory and quality control in the laboratory and several criteria as presented in Figure 3 above. Therefore some metrological tools such as traceability to SI units and reference materials (RMs) play an important role in data quality assessment during the compilation process, where they are used as criteria for evaluating the analytical quality of values. Furthermore, when it comes to the interchange of data between compilers, reference materials serve as criteria for data comparability, and SI units are used to ensure comparability of single or aggregate values that enter Food Composition Databanks

During the EuroFIR Nexus project, funded by the European Commission, guidelines were developed for assessment of quality management processes used by nFCDB compilers (Unwin et al., 2016; Westenbrink, Roe, Oseredczuk, Castanheira, & Finglas, 2016). Under this framework a programme of peer review assessment of compilers took place. The aim of the peer reviews was to identify the strengths and weaknesses of each compiler organization and to improve quality systems through identification, benchmarking and dissemination of 'best practice' as described in EuroFIR guidelines. More than twenty compilers organizations were visited. The reviews showed that compiler organizations had made good use of these guidelines. This was a landmark to further the common understanding of the EuroFIR quality framework as a pillar of harmonization of food composition databanks across and beyond Europe.

EuroFIR went on to develop guidelines for assessment of analytical methods (GAMA) in order to assist compilers further (Castanheira, Saraiva, Rego, & Ollilainen, 2016). Procedures have since been implemented and tested by a group of compilers under the EuroFIR Nexus framework. The system has been refined and expanded for all EuroFIR compilers for multi-nutrient data evaluation (Westenbrink et al., 2016).

Conclusions

The assessment of quality management systems used by compiler organizations is an important part of EuroFIR activities. A policy of quality at the highest level can be extended to the international food composition arena to further build on previous initiatives in order to improve the traceability and reliability of nutrient values and bioactive compounds. These advances will have a considerable impact in the emerging field of metrology in food and nutrition and increase user confidence in food composition data across European countries, and beyond.

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Planning a food composition study

Dr Judy Cunningham, Consultant

Introduction

This paper presents personal experiences and lessons learned from many years of performing and commissioning food composition studies in Australia. It is not based on a comprehensive literature survey of all aspects relevant to this topic.

1. Understanding the study purpose

Understanding the purpose of a particular food composition study is the most important question to address in planning such studies. Studies must be designed to answer a specific question, or there is a risk of generating data that are not suitable to use. No single study design is appropriate for all food composition studies. Food composition data are expensive to generate and most researchers cannot afford to get inappropriate or incorrect data that do not fit the intended, specific purpose.

There are many reasons for doing food composition studies and therefore many types of study designs. In order to help determine the most appropriate design for a study, questions such as the following must be answered:

- What is the purpose of this food composition study? There are many reasons for such studies, including: developing national food composition tables, preparing a database for a national nutrition survey, carrying out a risk assessment, studying crop variation, food product labelling, and promoting a food, or to support an epidemiological survey. The end uses of the data help to determine study design.
- What decisions will be based on the study results? Will people develop public health initiatives? Develop agricultural programs? Allow fortification of foods? Buy products because of these data? Sue someone because of these data?
- What foods and nutrients are of interest? The whole diet? Just one type of food? Products of a specific company or a range of similar products? Different varieties of a fruit or vegetable? Just one nutrient? Many nutrients?

Only the study manager can fully answer these questions; however the study manager cannot answer them alone and needs input from other key people in the area. Much background research is needed and it is worthwhile setting up a small project advisory team. The team does not have to be a large, formal one but should include people with a range of skills and backgrounds who can help to plan the survey and to interpret the results.

Once a survey plan has been developed and work starts to proceed, it is important to regularly re-evaluate what is being done to ensure it still meets the needs and purpose of the study.

2. Scientific planning

Once the study purpose has been determined, it is vital to consider some of the scientific issues that are pertinent to the study. Depending on the study purpose, ask questions such as the following:

» What foods do people in my country or study population buy and eat? How do they cook and store these foods? Where do they buy them and what regions do the foods come from?

» What nutrients are of interest and are there other related nutrients we need to know about (e.g. just omega 3 polyunsaturated fatty acids or all fatty acids; sodium if studying iodine from iodised salt; moisture content)?

» What foods are likely to be sources of the nutrient(s)? Consider both likely levels in foods and how much people eat of that food, because both factors are relevant when doing a study that estimates population nutrient intakes.

» How are levels of the nutrient(s) affected by factors such as transport, season, variety, cooking method, packaging, storage, handling in the laboratory?

» What methods of analysis are available for the nutrients that are to be analysed? Are these methods likely to be suitable for all the included foods? For example, will they be able to measure very low levels reliably? What reference materials are available and relevant? Are there laboratories in our region that can carry out these analyses?

» Are there any relevant laws that might affect nutrient levels? This is particularly relevant if studying a nutrient that may be present in fortified foods.

A useful guide to the practicalities of planning a specific food composition study is provided by Greenfield et al (2008). Vannort (2013) summarizes the planning of a total diet study and contains material that is also relevant to food composition studies.

3. Administrative planning

Consideration of issues such as budget and timelines are just as important to the success of a food composition study as are the scientific issues. Ask questions such as the following:

» What is the budget? In large scale projects, budgets may be phased over several years so the right amount of money must be available at the right time. Consider also setting aside a small proportion of funds for contingencies, such as the need to repurchase and re-analyse samples. The budget needs to cover sample purchase and transport, as well as preparation and analysis, in addition to staff budgets.

» Are there people with the right skills, and availability (e.g. staff, students, volunteers) who can help? The following skills are very useful in team members or advisers:

- Someone who knows how to cook
- Someone who knows the food supply
- A subject-matter expert (e.g. dairy production expert, iodine nutrition expert, nutrient analysis expert)
- People who are good with data
- People who love detail and are patient and persistent.

» How will these people be trained? Even subject matter specialists will need to be briefed on the specifics of the survey and their role in it. Do not take for granted that team members understand what is expected of them.

» What is the timetable for this work? Can the study be completed within the time available? If not, consider an alternative approach. Experience has shown that rushing a project to get it completed on time can lead to poor results, for example because there was not enough time to develop a robust sampling plan, or because there was not enough time to review analytical results and request re-analysis if necessary. Ensure time is allowed to review data when received, and to write a report on the study outcomes.

Having considered the above scientific and administrative matters, and identified the minimum amount of quality work that can be done to achieve the study purpose, the study manager should stop and consider whether or not the food composition study can proceed as originally conceived. If it can proceed, then a formal project planning phase should start. This will include matters such as writing instructions for sample purchase and handling and working with laboratories to get cost quotes and identifying any analytical and logistical constraints that may not previously have been identified.

If it is felt that a quality study cannot be completed with the time and resources available, the study manager should consider whether to refine the study purpose and/or seek funding partners. At this point, it may be appropriate to think about whether or not some suitable data could be found elsewhere (see section 6., below).

4. Understanding what foods are available and consumed

To assist in determining the types and amounts of foods eaten in your country or region, and therefore what foods to include in the survey, the following data sources could assist:

» National nutrition surveys. In Australia, recent, nationally representative food consumption data are available at: http://www.abs.gov.au/australianhealthsurvey. In New Zealand data are available at http://www.health.govt.nz/nz-health-statistics/national-collections-and-surveys/surveys/current-recent-surveys/nutrition-survey.

» FAO/WHO databases: (http://www.who.int/foodsafety/databases/en/), including the GEMS/Food cluster diets and FAO/WHO Chronic individual food consumption database – summary statistics (CIFOCOss. http://www.who.int/nutrition/nlis/en/)

» Other sources of consumption data can include:

- Company sales data, for manufactured foods
- Supermarket sales data (if available and affordable)
- Scientific literature. For example, there may have been a study on maternal nutrition in the region that may give some insight into eating patterns.
- Field visits to relevant food outlets. In supermarkets, the amount of shelf space for a food may be a guide to its sales. In fresh produce markets, several visits over time may give information on seasonal availability.

5. Overcoming practical issues with sample collection

Getting the right samples is fundamental to a quality outcome. No amount of analytical rigour will overcome the purchase of the wrong samples and poor handling of these samples. The following points do not address the important issues of the number of samples required and how selection of representative sub-samples should be determined, but focus on some practical issues with sample purchase, transport and handling.

- Equipment needed to collect food samples. For example, will liquid samples need to be decanted into leak-proof containers? How will samples be wrapped after purchase to avoid them drying out or getting damp? How will they be labelled? Equipment is likely to be needed to protect samples from excessive heat, light and air.
- Sample collection location (e.g. farms, markets, factories, supermarkets, restaurants, homes). The location of sample collection depends on the purpose of the study (see earlier). For example a study of the effects of horticultural conditions on vitamin levels may sample directly from one or more farms, whereas a study designed to estimate population nutrient intakes may sample at supermarkets or even in homes.
- Is it safe to collect samples? Consider things such as remote locations, areas of crime (especially if samplers are carrying cash to purchase samples), any risk with collecting sample from production lines or on-farm, weight of the samples that need to be collected (there may be many kilograms of food to be lifted and carried).
- How long will sampling take? Sampling often takes a long time as it generally carried out across multiple sites with travelling required between sites. It may be necessary to sample over several days or with a number of samplers at the same time.
- How will purchase of the correct samples be confirmed? It is common for the people doing the sampling to select incorrect samples. This may happen when a specific food is not available, or the sampler has not fully understood the instructions. If possible, review photographs or other information prior to analysis so that time and money are not wasted on analysis of the wrong samples.
- Are there cultural sensitivities to consider in sample collection? For example, is special permission needed to enter certain places? Does the local community need to be briefed about the purpose of the study?

It is recommended that the study manager takes a draft set of instructions into the sampling environment to test their clarity and to identify required equipment, possible hazards and other challenges that may arise.

Transport of samples after purchase is a major logistical issue. Food is perishable and therefore long delays between purchase and analysis need to be avoided. The following factors must be considered, as a minimum:

- What are the transport options for samples? What is transport likely to cost? Air transport may be the only solution if you need to sample in remote locations or in a number of different cities in a large country, such as Australia. However air transport can be very expensive. Refrigerated road transport may be a more cost-effective option depending on infrastructure in the area. In a small study, it may be possible to use a car containing coolers/eskies to travel between purchase sites and the laboratory.

- Are special containers needed for transport? Since most foods will need to be kept cold, they may need to be packed in insulating containers with ice bricks (or similar). Depending on the analyte of interest, it may be important to use special materials that do not contaminate the samples.
- How long will it take to get samples from the point of purchase to the laboratory? It is not unknown for samples to arrive at the laboratory already spoiled. Delays in transport can occur, for example, if samples are collected on Friday but the transport company does not deliver until the following Monday. Samples that are spoiled on arrival should be discarded and new samples obtained.
- Will the laboratory be able to manage and store a lot of samples? Many laboratories have limited space to prepare samples and then to store them before analysis. It is important to liaise with the laboratory manager to develop a sampling plan that reflects their needs. For example, different foods may need to be sampled on different days so that the laboratory is not swamped and sample quality compromised.

6. Can data from other sources be used instead?

Once detailed planning for a food composition study gets underway, it may be apparent that the challenges are greater than had been anticipated, and the study cannot be completed within the time and funds available. It may be necessary to consider using some data from elsewhere instead.

Whether or not it is appropriate to use data from elsewhere depends on:

- the purpose of the study
- whether there is any relevant, quality data available
- the quality of existing data
- the relevance of existing data
- whether or not permission is required

Relevant food composition data may be found in the following places:

- The FAO INFOODS site, which provides links to national and regional food composition tables, many of which are available online (see http://www.fao.org/infoods/infoods/tables-and-databases/en/).
- In Australia, NUTTAB (FSANZ 2011); in New Zealand, Food Files (IPFR 2015). There are also Pacific Islands Food Composition tables (Dignan et al 2004), available on the INFOODS site.
- The published scientific literature may contain data that are useful and not present in national tables.
- International and national group websites.
- Theses and unpublished studies.

In order to try to assess the quality of any data located, consider the following, among other matters:

- Are the data from a credible author or organization?
- Is the food clearly named, giving information on how it was prepared and cooked?
- Is the age of the data provided?
- Is the method of analysis identified?
- Are the number of samples and standard deviations provided (noting this is sometimes not provided in food composition tables)?
- If the data are calculated by recipe, is the recipe provided?
- Is there supporting information available about limitations of the data?

In national or regional food composition tables, this information may be found in supporting documents, rather than within the actual data tables.

Having found some data that appear to be of appropriate quality, the relevance of the data needs to be considered. Just because data are of good analytical quality, does not automatically mean they are relevant for the study purpose. The following are some matters that should be considered:

- Do people eat the same foods in our country/region? For example, do they eat the same varieties of a fruit, do they have the same fortification practices, how does the amount of fat in meat products compare?
- Are cooking methods the same or similar? For example, are the same types of oils and fats used, are similar amounts of salt and sugar added?
- Are the provided portion sizes relevant to our country?
- Does the dataset cover the required nutrients and use the same definitions of these nutrients?

It is more likely that data from other countries are appropriate for use if the foods in question are internationally traded commodities such as coffee. Perhaps a country imports all its beef, for example, from Australia, and therefore the use of Australian beef nutrient data may be appropriate, providing that the cuts imported have similar amounts of trimmable fat and are in similar sizes (if data on portions eaten are also required). Levels of micronutrients may be impacted by factors such as soil type or variety grown, therefore it is important to be cautious in using borrowed data if the population under consideration eats primarily locally grown produce.

7. Limitations of food composition studies

Every food composition study will have limitations as it will never be possible to design a perfect study. It is important to identify these limitations early in the project and to let data users know what they are. The study manager will have to make some compromises between quality and quantity of data as, in practice, it may not be possible to commission enough data analyses. This is one reason why it is essential to understand the study purpose, so that the study manager can determine when compromise is, or is not, reasonable.

Mistakes do occur in food composition studies, particularly large studies. The wrong samples may be purchased and analysed, analytical mistakes may occur or unexpected analytical challenges arise. Sometimes data will be generated that cannot be used. The known limitations should be documented and set out in User Guides.

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Scrutinizing Food Composition Data

Dr Judy Cunningham, Consultant

Introduction

This paper presents personal experiences in scrutinizing food composition data, particularly data generated from single analytical studies of a limited range of foods. The scrutiny of large datasets is covered elsewhere in this document.

Scrutiny typically refers to the critical examination of something. Data scrutiny in the context of food composition data means carefully examining all received data and questioning anything that does not look 'right' or is missing. Scrutinizing new analytical data is the same as checking any other purchase that is made – to satisfy oneself that you got what you paid for and that it is of good quality.

Scrutinizing for completeness

When analysis of a group of foods has been commissioned or received, it is important to check firstly that everything required has been done and the results provided. Some of the information requested from a laboratory may not be captured in the laboratory's information management system and it is easy for this information to be forgotten. Some simple checks for completeness include:

- Has all required information been provided - foods, nutrients, portion sizes, photographs, purchase information?
- Were the right samples analysed?
- Has the method of analysis been identified and is it the one specified?
- Was the required LOR/LOD achieved? If not, why not (this may be related to sample matrix issues that were not apparent during the planning stage)?
- Were quality assurance data provided if required?
- Are the results provided in a usable electronic format?

It is preferable to do this initial scrutiny as soon as the results are received from the laboratory, as it becomes harder to find missing information if there is a delay.

Scrutinizing the analytical results

There are many tests to do at this point. Many of the basic checks are outlined in Greenfield & Southgate (2003). Some broader issues to consider include:

- Do the data make sense? What 'story' do they tell?
- Are the expected results achieved? If not, why not? For example sometimes foods that are supposed to be fortified may not be, and *vice versa*.
- Were QC results acceptable? (e.g. recovery, precision of duplicates and replicates, standard reference material results)
- What is the overall quality of the data and can they be used for our purpose?

To help with data scrutiny, consider reformatting the results received into an arrangement that facilitates checking. First of all, protect the original version of the electronic results by using security features built into the software and work only in a copy of the original results. For this author, grouping similar foods together and then ordering data with each nutrient in a separate spreadsheet column helps to quickly identify patterns in the data and values that are inconsistent with other values. In doing this however, do not re-enter data (which may introduce typographical errors) but use features such as transposing data or simply cutting and pasting; check errors have not been introduced after this has been done.

It is worthwhile then to look at each food separately, such as:

- Moisture – is the reported level what was expected or does it seem too dry (the food has been overcooked) or too moist? Both high and low values can indicate problems with sampling handling and storage.
- Protein – is the correct nitrogen factor used?
- Ash – is this higher in high salt foods?
- Starch – is this lower than expected? Does this suggest a new analysis for resistant starch is needed? This may be a particular problem in baked cereal products.
- Units used. Some laboratories routinely report minerals on a per kilogram basis, whereas most food composition tables report values per 100 grams. Sometimes values may be reported in milligrams whereas they are needed in micrograms.

This author's preference is to work from the raw analytical data and not to use any calculated or derived values estimated by the laboratory. This ensures derived values are generated using preferred or required factors, which may not be the same as those used by the laboratory. Convert any values in different units to the units required for the study, rather than relying on the laboratory to do this (e.g. convert iodine values reported in milligrams per kilogram to micrograms per 100 g).

In checking reported nutrient values, do not forget to also check other information given, including portion size and specific gravity information.

Inevitably there will be some problems in the results received. Critical examination of the results will identify these, from which it is necessary to work with the laboratory to explore potential causes. This is greatly assisted if a good working relationship with laboratory staff is established at the outset.

Scrutinizing other peoples' data

Sometimes, particularly if a large food database is being compiled, data may be provided from other groups. If possible, a similar data scrutiny approach should be applied to these data. Do not assume that the person or group providing the data has carried out a detailed review of it. In particular, ensure that all information on sample origin (where, when, how many sub-samples etc.) and sample construction (number of sub-samples, preparation etc.) is provided. As with one's own analytical data, it is preferable to do this as soon as possible while memories are fresh.

Scrutinizing recipe calculated nutrient data

The use of a recipe calculation system to generate new nutrient data is an established practice in food composition databases. Well-constructed recipes maximize the amount of useful information that can be derived from expensive analytical data. Some factors to consider when developing recipes for nutrient calculations, or when scrutinizing data that other people have developed, include:

- Does the recipe approach suit the purpose? For example, if estimating sodium levels in foods, check that recipes used include added salt or sodium-based food additives, where relevant.
- What type of oil or fat is used? Choice of cooking oils differs between countries and a set of recipes developed for one country may not be appropriate in another country if the oil type is different.
- How are the effects of cooking on nutrient profile dealt with? If raw ingredients are used, have appropriate nutrient retention factors been applied to account for change in nutrient levels due to cooking? Have weight change/yield factors been applied?
- Have the recipes been validated, for example by comparison with appropriate analysed values? This may help to identify whether or not weight change factors are likely to have accurately estimated moisture content and therefore levels of other nutrients.
- Have appropriate checks of the calculation algorithms been done?

Conclusion

Thorough data scrutiny is a very important step in ensuring that the overall quality of new food composition data is acceptable.

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Use of Information Technology in Data Scrutiny

Renee Sobolewski, Senior Scientist,
Food Standards Australia New Zealand

Background

The focus of this paper is on the use of information technology to help food composition data compilers to scrutinize large sets of data and thus to improve overall data quality. It is not intended to replace the need for careful scrutiny of data for individual foods as this is received from laboratories and compiled with other data to make a complete set of nutrient data, for example for publication in national food composition tables.

Scrutinising large datasets

When presented with a large set of nutrient data for checking, it can be difficult to know where to start and how to format and view data to help. Due to the size of some datasets manual checking of compiled data is not a realistic option.

For example, when Food Standards Australia New Zealand (FSANZ) published AUSNUT 2011-13, the survey database of nutrient and other values that was developed to support estimation of population nutrient intakes as part of the Australian Health Survey (FSANZ 2014), there were almost three quarters of a million data points to check. Checking was not just limited to the nutrient data, but all the data intended for publication. In terms of quality, it was just as important to get the measures data correct as the nutrient values. This required checking of:

- Nutrient data for foods and drinks – each of the 5,740 foods and drinks had 53 separate values, leading to over 304,000 data points
- Nutrient data for dietary supplements – there were over 75,000 data points here to cover each of 35 nutrients included
- Measures/portion data – there were 16,000 individual measures included, and a total of more than 250,000 values (numeric and alphabetical)
- Recipe data – 3,646 foods had their nutrient values developed using a recipe, totalling 36,460 data points
- Metadata – including descriptions, derivations, references etc. (>93,000 data points).

Scrutinizing datasets of this size needs a practical approach. The following made this process easier:

- prioritizing the data checks required
- formatting the data in a sensible and easy to interrogate way
- automating as many checks as possible using the IT options available.

Prioritizing the dataset included deciding matters such as:

» Being clear on the purpose and likely use of the data, to help in ensuring the most critical data are right. In the case of AUSNUT 2011-13, because the data were being used for estimating population nutrient intakes from the Australian Health Survey, FSANZ prioritized checking to focus on the most commonly consumed foods and measures as mistakes could have had a large impact on the final estimates. In checking AUSNUT, the focus was also on foods that were likely to be good contributors to intake of specific nutrients or in particular age groups, even though they may not be a widely consumed food (e.g. liver for its contribution to retinol intake).

» What are the areas where the greatest concerns arose when compiling the data? In the case of AUSNUT 2011-13 there were a few food categories (e.g. biscuits) where the underlying data were quite old. As only limited funds were available for new nutrient analysis, in this situation the data were sent to the relevant food industry to review and to confirm its currency.

» Do the checks need to be carried out in a specific order? Because of the structure of the FSANZ nutrient data management system, it was necessary first to make sure the fat factor and nitrogen factors used in calculations were correct before checking the nutrient profiles that were based on these factors. It was also important to make sure the nutrient profiles for analysed foods were correct before focusing on our recipe calculations, because the recipe calculation process uses the data for analysed foods.

Using information technology to assist

Formatting the data to be scrutinized is important so that the data are in a layout that helps, rather than hinders, checking. Although the layout chosen is somewhat subjective, experience has shown that working with clean data that is formatted in a logical way enables patterns and outliers in the data to be easily identified and the use of software tools to be maximized.

The following formatting approaches helped with AUSNUT:

» Designing report layouts so that only related data was included in specific reports, leading to a series of different reports rather than all possible data in a single, unmanageable report.

» Assigning a sort order that groups similar foods together, to make it easier to identify patterns in the data.

» Using Microsoft Excel to help organize, interrogate and publish data. It is particularly useful for summing values for checking, looking up values between files and spell- checking.

Some useful Microsoft Excel tools to organize data include:

» Sorting and filtering

» Data grouping and ungrouping

» Splitting and freezing panes

» Consolidation.

When focusing on ‘organizing’ data there are a lot of options found on the ‘Data’ and ‘View’ tabs of Microsoft Excel.

Useful tools for scrutiny of organized data include:

» Sum/average/min/max – summing data is mostly used to check the sum of proximate components and the sum of fatty acids

» V-look up - commonly used to add and compare data between files, because the data in each of the files will not always be in the same order. When doing a V-look up, the value used to look up the data between the two files needs to be unique (if it does not exist one should be created by using the concatenate function), an exact match (often there can be spaces at the end of a field, which can be removed with the trim function) and be placed to the left of the data being referenced (reorganization of columns may be required).

» Trim

» Concatenate

» Exact

» Count

» Length

In terms of data scrutiny, most options can be found on the formulas tab.

Conclusion

There are many tips and tools that can be used to assist with the scrutiny of large datasets. However, even with the use of information technology, when very large datasets are compiled there remains a need for a final manual review of the data to ensure a high level of accuracy.

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Regulatory Monitoring of Fortified Foods in the Pacific - Ensuring a Public Health Benefit

Presented by Glen Maberly on behalf of the Food Fortification Initiative (FFI)

What is fortification?

Food fortification is adding essential micronutrients (vitamins and minerals) to improve the nutrition of staple foods. The Food Fortification Initiative (FFI) provides advocacy and technical support to national governments to plan and implement mandatory fortification of industrially milled wheat flour, maize flour, and rice to provide a public health benefit.

An estimated 2 billion people worldwide have one or more deficiencies of iron, zinc, vitamin A, iodine, and folate (WHO, 2017); consequently these are often the nutrients used in fortification programs. Fortification can help address anaemia caused by inadequate nutrition. In the United States for example, folate-deficiency-anemia has been nearly eliminated after fortification (Odewole et al. 2013). In addition, fortifying with folic acid (the form of folate used in supplements and fortification) is one of the most effective ways to prevent serious birth defects of the brain and spine, or neural tube defects (Castillo-Lancellotti, Tur & Uauy, 2012). If the infant does not die soon after birth, these are life-long conditions that require multiple surgeries and rehabilitation. Furthermore, zinc and several of B-vitamins, such as thiamin, riboflavin, and niacin, support the immune system, which helps make the body less susceptible to skin problems and other illnesses.

Because no one intervention will solve an entire country's nutritional needs, fortification is complementary to other elements in a national nutrition strategy (e.g. dietary diversity, supplementation, biofortification, etc). Fortification is an effective, as well as cost-effective, way of delivering nutrients to a broad population. It is successful, in part, because it does not require consumers to change behaviours; the foods they already eat simply have more nutrition.

Fiji's wheat flour fortification success

In Fiji, a national nutrition survey in 2004 (before mandatory wheat flour fortification) (Schultz, Vatucawaqa & Tuivaga, 2007) compared with 2010 (post-fortification) showed improved iron, folate, and zinc status as well as lower anaemia in women of reproductive age (Figure 1) (Schultz & Vatucawaqa, 2012).

Table 1: Success of wheat flour fortification in Fiji

Deficiency	2004 (Before fortification) %	2010 (After fortification) %
Iron	22.9	↓7.9
Folate	8.1	↓1.0
Zinc	39.3	↓0.0
Anaemia	40.3	↓ 27.6

Global fortification practices

FFI monitors the legislative status of mandatory grain fortification programs (Figure 1). In total, 86 countries have mandates to fortify at least one staple grain with iron or folic acid. Most countries include both except for the following: Australia does not include iron; Congo, Papua New Guinea, the Philippines, the United Kingdom, Venezuela, and Vietnam do not include folic acid.

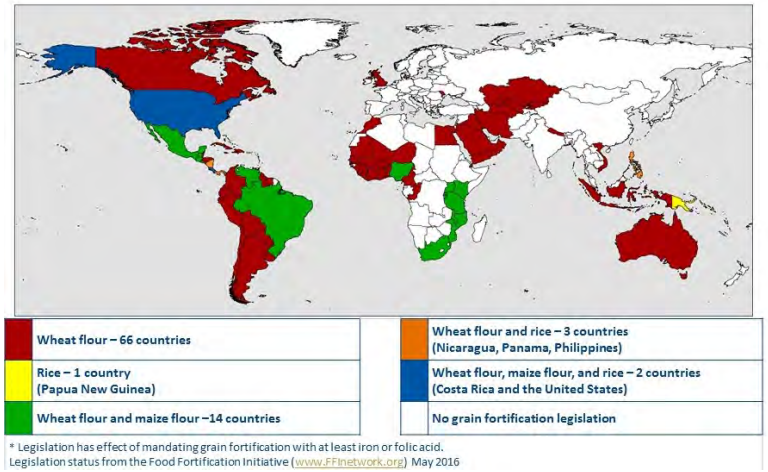

Figure 1: Industrially milled flour and rice fortification mandatory legislation (Food Fortification Initiative, 2016)

Oil fortification and salt iodization in the Pacific

FFI does not work in oil fortification or salt iodization, but both are relevant to food fortification in the Pacific. Salt iodization is more common than grain fortification; 127 countries have mandatory legislation for iodization of salt (Figure 2, below).

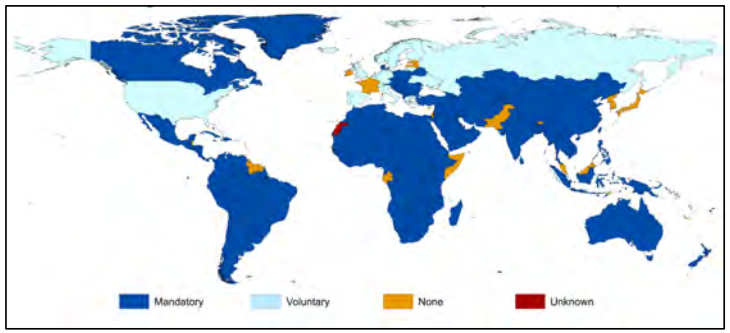

Figure 2: Global salt iodization status (Iodine Global Network, 2016)

About 20 countries have mandatory fortification laws for edible oils (Figure 3).

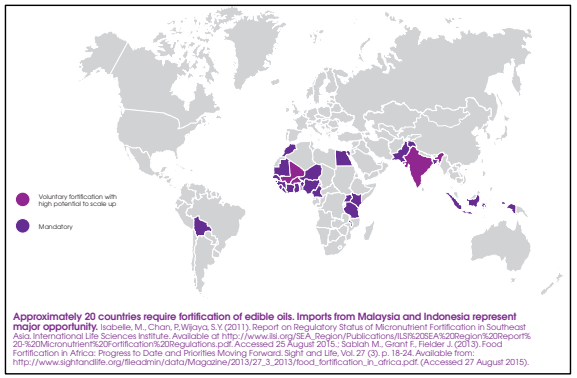

Figure 3: Global status of oil fortification globally[1,2]

[1]Global Alliance for Improved Nutrition

[2]FFI confirmed Philippines has a mandatory law but is not noted in this map.

Fortification status in the Pacific for wheat flour, rice and salt

Table 2 lists fortification status in the Pacific for mandatory fortification for wheat flour, rice, or salt. Several Pacific Islands are territories under the jurisdiction of another country. It is less clear whether these territories have the same fortification status as the jurisdiction country and whether it is implemented or not.

Table 2: Fortification status in the Pacific for wheat flour, rice, and salt, (Food Fortification Initiative, 2016; Iodine Global Network, 2016)

Wheat flour	Rice	Salt
Australia	Papua New Guinea	Australia
Fiji		Fiji
Solomon Islands		New Zealand
		Papua New Guinea
		Solomon Islands
		Vanuatu
Territories under the jurisdiction of a country with mandatory fortification		
American Samoa (US)		American Samoa (US)
Christmas Island (Aus)		Christmas Island (Aus)
Cocos Islands (Aus)		Cocos Islands (Aus)
Pitcairn (UK)		Pitcairn (UK)
North Mariana Islands (US)		North Mariana Islands (US)
Norfolk Islands		Norfolk Islands

The legislative process for fortification

The most important first step is securing sustained political commitment to pass legislation, as political will is essential for successful mandatory fortification. This is a long-term nutrition intervention that often addresses invisible public health problems, which may make it difficult to convince politicians to commit several years to introducing and supporting legislation.

Preparing for food fortification should also involve: 1.) selecting an appropriate food vehicle based on industry capacity to fortify and consumption patterns; 2.) selection of nutrients to include.

Usually one piece of legislation makes fortification mandatory, and another piece of legislation is a standard or regulation that defines how fortification should be implemented. However, this may not always be the case. In Papua New Guinea (PNG), only one legislation (Food Sanitation Regulations 2007) creates the mandate for fortification, and a section of it defines the nutrients to add. Also consider whether fortification should be incorporated in other legislative documents. In the Solomon Islands, the currently proposed Import Food Control regulations specify that mandated food fortification is one of the criteria for foods of regulatory interest. This allows health inspectors to place scrutiny on mandatorily fortified wheat flour and rice at border.

What is regulatory monitoring?

Regulatory monitoring is the assessment of the quality control system at production, import, or retail. Activities, usually carried out by a government agency, are: ensure compliance with national regulations on food specifications, by both food producers and government agencies. In PNG and Solomon Islands, the Environmental Health Unit of the Ministry/Department of Health is responsible for regulating compliance with fortification. Regulatory monitoring can also refer to the quality control/quality assurance (QAQC) activities (also called internal monitoring) conducted by food manufacturers to document fortification during production. Internal documentation by food manufacturers can be used by government agencies during operations auditing.

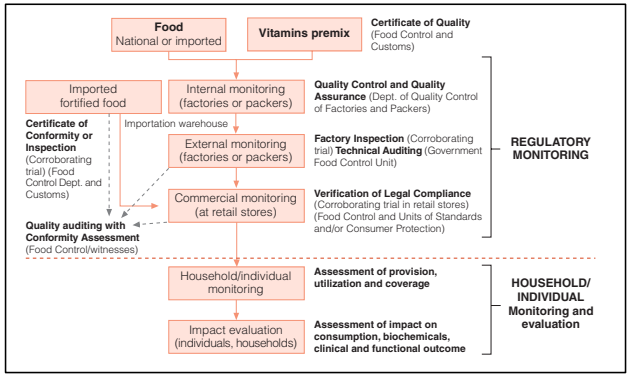

Figure 4: A monitoring and evaluation system for food fortification programs (WHO/FAO, 2006)

Commercial monitoring at retail sites can also take place, but because most countries have many more retail sites than food producers, commercial monitoring can require more resources than monitoring at point of production or import. However, commercial monitoring can be useful for catching illegal imports that are not caught during import monitoring.

Fortificant/premix monitoring

Individual nutrients added via fortification are called fortificants. They are often combined in a powdery blend called premix to add to flour. The first step for regulatory monitoring is to ensure the quality of fortificants or premix and that they conform to the national fortification standard. This is usually most relevant to imported fortificant and premix. If premix is domestically produced, the facility is likely under many other food safety regulations.

At border, officials should see that the product is accompanied by a certificate of analysis to confirm its contents. On a periodic basis, laboratory testing to verify the certificate of analysis can also be conducted as resources allow.

Internal monitoring

Modern food manufacturers usually already have internal monitoring to ensure they are producing quality products that meet customer expectations, especially if they produce for export requirements. Internal monitoring for food fortification refers to specific monitoring activities integrated into existing QAQC system. For iodized salt and iron-fortified wheat flour and rice, a rapid spot test can identify whether iodine or iron respectively is in the end product. Rapid spot tests for nutrients are a quality control activity.

Quality assurance refers to processes to check quality during production. Quality assurance can include sourcing of high quality inputs and equipment, recording the use and storage of those inputs, recording the production processes, and then the final output. It also includes checking equipment systematically to make sure it is operating properly. For example, a miller check-weighing the premix from the mill's feeder in order to check whether the correct amount of premix is a quality assurance activity.

External monitoring

External monitoring by the government takes place where food is fortified – a wheat mill, rice mill, oil refinery, or salt refinery. Usually these facilities are inspected for food safety purposes; to save resources, fortification inspection can be added to existing protocols. Inspectors should inquire about and observe relevant QAQC processes for food fortification, gather documents for auditing, and also periodically sample end food products for analysis.

Import monitoring

Import monitoring of food is done at border control sites. Because so much food is imported in the Pacific context, the import control system has huge implications for monitoring safety and quality of the national supply of food. As part of import monitoring, inspectors review the paperwork submitted in advance of a shipment of fortified food entering the country (e.g. certificate of analysis for fortified wheat flour). Periodic lab testing of imported foods of regulatory interest will also help provide a check against falsified paperwork. For salt, wheat flour, and rice the rapid test can be used at point of entry to immediately check products; shipments do not need to be held.

Commercial monitoring

Commercial monitoring is when government inspectors go to retail outlets. An inspector visits shops, talks with the proprietors about the source of the flour they sell, and reviews the labels on the flour. In Costa Rica, commercial monitoring is done at bakeries to inspect the flour used for making products.

For external, import and commercial monitoring, inspectors may take fortified food samples to be analyzed qualitatively or quantitatively to determine if they are fortified.

Regulatory monitoring in the Pacific context

Unique considerations to the Pacific are: 1.) limited resources for food safety compared to biosecurity; 2.) lack of consideration of fortified foods in the context of food safety; 3.) unclear or inefficient roles and responsibilities between government agencies at border control points.

Because many Pacific countries are islands, biosecurity is emphasized and resourced. For example, from FFI's experience at border control points in PNG and Solomon Islands, biosecurity officers have greater presence than food safety officers who are responsible for fortification.

Also, food safety officers generally do not prioritize inspecting fortified foods because these items are not considered high-risk – individuals will not fall ill if a food is not fortified adequately. However, if fortification is legislated, non-fortification can justifiably be considered un-safe. Although non-fortified foods will not cause immediate illness, they put consumers at greater risk for long-term health conditions.

Lastly, clear roles and responsibilities between government agencies could help save time and money in the regulatory monitoring system. Currently agencies in PNG are discussing roles and responsibilities between Environmental Health for food safety, and National Agriculture Quarantine and Inspection Authority (NAQIA) for biosecurity. Customs and NAQIA are the only agencies with border control duties, i.e. these agencies have authority to reject imports at the border. Customs has the power to inspect goods for required taxes and dangerous and prohibited goods, such as drugs and weapons.

Clearly, for a functional imported food safety system, the three agencies must communicate between each other to agree upon and understand the roles and responsibilities different foods. Without this understanding, PNG will have gaps in food control and duplicated work.

It is critical that fortification does not become a special activity of only one group in the food control system. It makes little sense to require separate inspection of a facility for fortification when fortification can be included in the existing inspection schedule.

After monitoring is conducted, use an open and transparent system to share the results with other government agencies or consumers and to follow up actions after an inspection or analysis outcome.

Conclusions: Recommendations for feasible regulatory monitoring in the Pacific

Important lessons learned for improving regulatory monitoring in the Pacific:

1. Create a legal justification for inspecting fortification compliance. Have fortified foods added as a food of regulatory interest to allow an inspection mandate.
2. Clarify roles and responsibilities between government agencies, with documented protocols that inspectors are trained upon. Consider authorizing duty delegation across agencies if this allows for greater efficiency and conserves resources.
3. Focus on import control to catch high risk foods or noncompliant importers.
4. Integrate fortification into the system at internal and external control – so it doesn't become an expensive one-off activity that can be easily forgotten or cut.
5. Recognizing resources are limited, keep it simple. Focus on reviewing documents and auditing processes. Use rapid tests where possible because laboratory analyses are expensive.
6. And lastly, be open and transparent about monitoring activities and results. Producers will be more likely to comply if they see the government doing its role.

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Compilation of Data for the New Zealand Food Composition Database

Suba Sivakumaran (presenting author), Siva Sivakumaran and Lee Huffman,
The New Zealand Institute for Plant & Food Research Limited

Introduction

The compilation of food composition data (FCD) for national food composition databases (FCDB) is a key step to ensure the overall quality of the FCDB. FCD can be compiled by three different methods: direct, indirect and a combination of the two (Greenfield & Southgate, 2003). The direct-method FCD are derived from analysis carried out for the specific FCDB being compiled, whereas the indirect-method FCD are compiled from published sources, including international FCDB. However, data quality implies being 'fit for purpose' for which the data are used by a range of users, from international to individual (Rand et al., 1991). New Zealand Food Composition Database (NZFCDB) data are used in a spectrum of fields such as nutrition surveys and research, food labelling, developing nutrient profile criteria, identifying reformulation initiatives (e.g. salt reduction in processed foods), diet formulation to meet nutritional targets (e.g. sports nutrition, special diets), clinical practice by dietitians to assess a patient's nutritional status or nutrition risk, public health and education, as a benchmark to promote products to New Zealand and overseas markets by food manufacturers (e.g. Zespri Group Limited) and in research for breeding targets.

This paper explains how the FCD are compiled within the current programme (July 2015–June 2016) for the NZFCDB.

Data compilation

It is a great challenge for compilers to provide a higher quality FCD to a spectrum of users. In the current NZFCDB programme, the majority of the foods were analysed by the most preferred method 'direct analysis method' and the FCD was compiled following international guidelines and standards (FAO/INFOODS, 2012a, b, c, d; Food Standards Australia New Zealand , 2012; Greenfield & Southgate, 2003; Klensin et al., 1989; Rand et al., 1991; Truswell et al., 1991). This involved several key steps (Figure 1) and careful planning, documentation and execution.

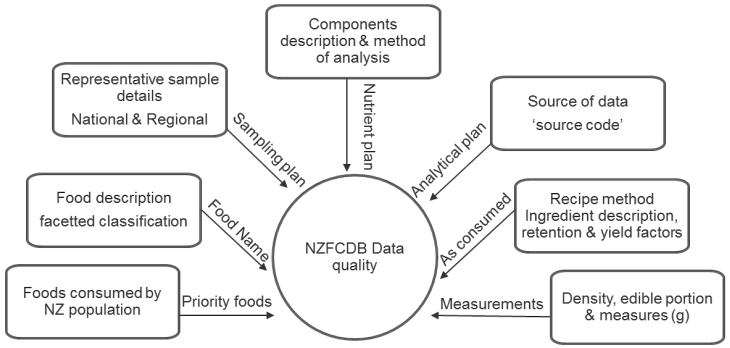

Figure 1: NZFCDB data quality and maintenance steps

Prioritizing foods

Every year up to 100 foods are added or updated, with the focus being on improving the quality of data for foods that contribute substantially to nutrient intake in New Zealand. These foods are new or replacements of the old food records in the NZFCDB and include staple foods, rich sources of nutrients, those used as ingredients in recipes, New Zealand produce and so on. Also considered are foods that may contribute to non-communicable diseases (e.g. high-fat foods) and to improvements in micronutrient deficiencies e.g. fortified foods with micronutrients. Fifty-four new food entries and 56 replacement foods for old foods that were analysed >10 years ago or borrowed from other sources were added to the NZFCDB for the current programme.

Food name and description

It is important to have a systematic food nomenclature system to group foods with similar characteristics; NZFCDB includes 22 food groups. Each food is uniquely identified by an alpha-numeric FoodID: a single letter denoting the major food groups, followed by one to four digits (e.g. L1077). Food names are constructed following the open ended, free-text, INFOODS multi-faceted naming system (Truswell et al., 1991).

Sampling plan

A sampling plan is developed and assessed to ensure that the foods sampled are representative of foods available to the public. National food sampling protocols are typically used for manufactured foods or imported foods. These foods are not expected to exhibit any regional variability. Such foods are therefore sampled from three or more supermarkets in the region where the compilers are based. Regional food sampling protocols are used for foods most likely to be produced, processed and consumed in regions near the consumption centre (e.g. fresh vegetables), where the method of production or the environment in which they are grown may introduce some variability in product composition. These regional or seasonal foods are sampled from major retail outlets throughout a number of regions, focusing on the five most highly populated regions: Auckland, Canterbury, Wellington, Waikato and Manawatu, which represent about 75% of the New Zealand population.

Nutrient plan

For each food, a complete dataset comprises 87 food components (Table 1). These are known as Core Components for the NZFCDB. These include energy, macronutrients (proximate), micronutrients (vitamins and minerals), derived components, macronutrient and some components expressed in different units and/or calculations. Each food component is identified by a tagname. Tagnames are designed to represent unique food components compiled by an expert committee under the auspices of the International Network of Food Data Systems (INFOODS). Tagnames incorporate the food component unit and the method of analysis or calculation. If a tagname is not available, a similar naming convention is used (Klensin et al., 1989; Sivakumaran et al., 2014).

The majority of the core components values are obtained by direct chemical analysis or calculated from the chemical analytical data with or without using conversion factors. Methods of analysis and algorithm for calculation of each food component can be found in the New Zealand FOOD files manual (Sivakumaran, et al. 2015). Chemical analyses are carried out using the standardized (in-house) and AOAC (Association of Official Analytical Chemists, 2005) methods at accredited laboratories in New Zealand and Australia. The laboratories are accredited by independent science-based organizations which have the authority to grant accreditation: International Accreditation New Zealand (IANZ , 2015) and the National Association of Testing Authorities, Australia (NATA, 2015). Accredited laboratories also have their own quality assurance programme in place.

Some food component values can be derived by the indirect method: these are presumed as zero where a food is not recognized to be a source of that food component, e.g. the dietary fibre value is zero for the food items raw egg and milk. Values for components present in small amounts are taken from published sources, including international FCDBs, and imputed from similar foods. Each food component value derivation source or type is represented with the one or more source codes (Table 2).

Table 1. Core components for the New Zealand Food Composition Database (NZFCDB) include INFOODS tagname1, component name and units per 100 g of edible portion.

Energy	ENERC - Energy, total metabolizable (kJ) [1]ENERC_FSANZ1 - Energy, total metabolizable, carbohydrate by difference, FSANZ (kJ) [1]ENERC_FSANZ1_KCAL - Energy, total metabolizable, carbohydrate by difference, FSANZ (kcal) [1]ENERC_FSANZ2 - Energy, total metabolizable, available carbohydrate, FSANZ (kJ) [1]ENERC_FSANZ2_KCAL - Energy, total metabolizable, available carbohydrate, FSANZ (kcal) ENERC_KCAL - Energy, total metabolizable (kcal) [1]ENERC1 - Energy, total metabolizable (kJ, including dietary fibre) [1]ENERC1_KCAL - Energy, total metabolizable (kcal, including dietary fibre)
Macronutrients	WATER - Water (g); ASH - Ash (g); ALC - Alcohol (g); FAT - Fat, total (g); PROT - Protein, total; calculated from total nitrogen (g); SUGAR - Sugar, total (g); STARCH - Starch, total (g); FIBTG - Fibre, total dietary Macronutrient fractions Sugars (g) FRUS - Fructose (g); GLUS - Glucose; LACS - Lactose; MALS - Maltose; SUCS - Sucrose Dietary fibre (g) FIBTG - Fibre, water-soluble; FIBINS - Fibre, water-insoluble Fatty acids (g) F18D2CN6 - Fatty acid cis, cis 18:2 omega-6; 1F18D2CN9T11 - Fatty acid cis, trans 18:2 omega-9, 11; F18D3N3 - Fatty acid 18:3 omega-3; F20D4N3 - Fatty acid 20:4 omega-3; F20D5N3 - Fatty acid 20:5 omega-3; F22D5N3 - Fatty acid 22:5 omega-3; F22D6N3 - Fatty acid 22:6 omega-3 ; FALCPUN3- Fatty acids, total long chain polyunsaturated omega-3; FAPUN3 - Fatty acids, total polyunsaturated omega-3; FAPUN6 - Fatty acids, total polyunsaturated omega-6; FAMS - Fatty acids, total monounsaturated; FAPU - Fatty acids, total polyunsaturated; FASAT - Fatty acids, total saturated; FATRN - Fatty acids, total trans Carbohydrates (g):

Macronutrients *(cont..)*	CHOAVL - Available carbohydrates by weight; CHOAVLM - Available carbohydrates in monosaccharide equivalent; [1]CHOAVLDF_FSANZ - Carbohydrate by difference, FSANZ; CHOCDF - Total carbohydrate by difference; CHOCSM - Total carbohydrates by summation; [1]CHOAVL_FSANZ - Available carbohydrate, FSANZ; CHOAVLDF - Available carbohydrate by difference
Vitamins	Vitamins VITA - Vitamin A, retinol equivalents (µg); CARTA - Alpha-carotene (µg); CARTB - Beta-carotene (µg); CARTBEQ - Beta-carotene equivalents (µg); RETOL - Retinol (µg) NIA - Niacin, preformed (mg); NIAEQ - Niacin equivalents, total (mg); NIATRP - Niacin equivalents from tryptophan (mg) FOL - Folate, total (µg); FOLAC - Folic acid, synthetic folic acid (µg), FOLDFE - Dietary folate equivalents (µg), FOLFD - Folate food, naturally occurring food folates (µg) THIA - Thiamin (mg); RIBF - Riboflavin (mg); VITB6A - Vitamin B6 (mg), VITB12 - Vitamin B12 (µg), Vitamin C (mg) VITD - Vitamin D; calculated by summation (µg), CHOCAL - Cholecalciferol (Vitamin D3, µg); ERGCAL - Ergocalciferol TOCHA - Alpha-tocopherol (mg), TOCHB - Beta-tocopherol (mg), TOCHD - Delta-tocopherol (mg); TOCHG - Gamma-tocopherol (mg); VITE - Vitamin E, alpha-tocopherol equivalents Minerals & elements Ca - Calcium (mg) ; Cu - Copper (mg); Fe- Iron (mg); I - Iodide (µg); K - Potassium (mg); Mg - Magnesium (mg); Mn - Manganese (µg); Na - Sodium (mg); P- Phosphorus (mg); Se - Selenium (µg); Zn – Zinc (mg).
Other	CHOLE - Cholesterol (mg); CAFFN - Caffeine (µg); NT - Nitrogen, total (g); TRP - Tryptophan (mg); DM - Dry matter (g)
Derived components	EDIBLE - Edible portion (%); DEN - Density (g/cm^3); Common Standard Measure (CSM, g)

[1] INFOODS tagname was not available, so generated for NZFCD using a similar naming convention.

Table 2. Common source codes and description of food component value derivation sources and types

Source code	Description
Z	Direct analysis - New Zealand analytical data
L	Direct analysis - less than detection limit
C	Calculated Calculated as recipe Calculated from component profile e.g. sum of sugar components Calculated including conversion factors Calculated from related foods Aggregated from contributing foods
R	Imputed from related foods
G	Estimated from ingredients of the food or other related foods
P	Presumed or logically zero
Borrowed from international FCDB or published sources	
A	Borrowed/imputed from Australian sources (e.g. NUTTAB, AUSNUT)
U	Borrowed/imputed from the USDA National Nutrient Database
B	Borrowed/ imputed from UK sources
D	Published sources including scientific literatures
0	Other international databases
h, s, j	Borrowed/imputed from Pacific Island sources

In the current programme, 41% of the data were derived from direct chemical analysis; 38% were calculated from chemical analytical data; 19% were presumed zero; and only 2% were imputed from similar foods for the 87 core components.

Analytical plan

Analytical data for a food can be obtained from a single composite sample, a multiple composite sample, or a combination of single and multiple composite samples (Cunningham, 1990). Single composite sample analysis is carried out for a specific food that has a unique food composition and contributes substantially to a nutrient of interest, whereas multiple composite sample analysis is carried out for foods with food components that contain similar ingredients. The composite samples are prepared based on the market share data (where available) or estimation on the shelf space allocation for brands and/or ranges in major retail outlets.

Recipes

The mixed-recipe calculation method is used where nutrient retention factors (NRF) are applied at the ingredient level, and yield factors (YF) are applied at the recipe level. Most of the YFs (weight, water and fat) have been determined by analysis and NRFs are taken from the USDA (U.S. Department of Agriculture, 2007). Recipe and component calculations are automated in NZFCDB using the internally developed Java-based application, Food Information Management System (FIMS).

Common Standard Measure and density

Household measures and weights (Common Standard Measures, CSM) of a food item are used to describe the standard quantities for research, nutritional planning and guidelines. CSM are either expressed as New Zealand metric standards (e.g. one cup – 250 mL) or as the amount commonly purchased.

Density is measured as specific gravity, mass density, bulk density, water displacement and/or rapeseed displacement methods.

Data entry and validation

All new analytical data are entered into the NZFCDB only after consultation with the analyst and subsequent confirmation of their accuracy. The validity checks are performed according to FAO/INFOODS guidelines (FAO/INFOODS, 2012b) before populating the dataset into NZFCDB and disseminating the database on the website www.foodcomposition.co.nz.

Summary

The current NZFCDB programme produces high quality data for the foods that contribute substantially to nutrient intake in New Zealand. There are 100 foods added to the NZFCDB, of these 53 foods are new foods and remaining 47 foods are replacement s for old foods. Seventy-nine percent of the data are derived by direct analysis (41%) or by calculation from analytical data (38%). The remaining 21% of the data are presumed zero (19%) or imputed from similar foods (2%) for the 87 core components. A faceted system is used to describe a food. This is helpful for users to find the best match for a food in the NZFCDB. The compiling protocols, planning and collection of metadata are documented and executed on a regular basis. The NZFCDB-related products are updated on this website regularly, and access is free of charge.

Acknowledgment

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Added Sugars in Foods – Quality vs Time in Database Preparation

Shari Tompsett, Senior Scientist,
Food Standards Australia New Zealand

Background

In 2015, the Australian Government Department of Health commissioned a project to determine the amount of added sugars consumed by Australians. The purpose of this project was to be able to compare Australians' intake of added sugars to dietary recommendations.

The Department of Health contracted the Australian Bureau of Statistics (ABS) to manage this project and ABS in turn sub-contracted Food Standards Australia New Zealand (FSANZ) to prepare data for the added sugars content of each of the 5,740 foods reported in the AUSNUT 2011-13 dataset (FSANZ 2014). The new dataset was provided to ABS December 2015, giving approximately six months for FSANZ to complete the dataset.

This paper sets out, briefly, the issues FSANZ had to address to develop a comprehensive added sugars dataset of a quality suitable for the purpose of estimating national intakes, within fixed time constraints. As the data were to be used for a project with a high level of public interest, and would be made widely available, quality and confidence in the data were paramount.

Defining the task

AUSNUT 2011–13 is a set of files published by FSANZ (2014) that enables food, dietary supplement and nutrient intake estimates to be made from the 2011–13 Australian Health Survey (AHS) which was managed by the ABS (ABS 2014).

AUSNUT contains data for total sugars but not added sugars; the total sugars value is estimated from the sum of fructose, glucose, sucrose, maltose and lactose. Many of the values for total sugars in AUSNUT are derived by laboratory analysis of these individual sugars; other values are derived by recipe calculation or imputation (FSANZ 2014). However 'added sugars' is not a chemical entity in its own right, and it cannot be determined through laboratory analysis separately from sugars that are intrinsic to a food. Therefore an alternative, non-analytical approach was needed to generate the required dataset.

Furthermore, *added sugar* has no universally agreed definition. An Expert Reference Group had been established to assist with this project and their advice was sought on the appropriate definition to use. Based on this advice, it was decided to use two related definitions: one to allow comparisons with recent advice on sugars intake from the World Health Organization (WHO 2015), and one based on the definition of sugars in the Australia New Zealand Food Standards Code (the Code) (FSANZ 2016). This means that two values were required for each food – added sugars and free sugars.

Sugars are defined in Standard 1.1.2 of the Code as:

a) hexose monosaccharides and disaccharides, including dextrose, fructose, sucrose and lactose; or
b) starch hydrolysate; or
c) glucose syrups, maltodextrin and similar products; or
d) products derived at a sugar refinery, including brown sugar and molasses; or
e) icing sugar; or
f) invert sugar; or
g) fruit sugar syrup; derived from any source, but does not include –
h) malt or malt extracts; or
i) sorbitol, mannitol, glycerol, xylitol, polydextrose, isomalt, maltitol, maltitol syrup or lactitol.

Although the Code definition indicates that *sugars* includes maltodextrin and similar products, these ingredients have not been captured in the components included in the added sugars amount in the dataset. This decision was made to maintain consistency with the definition of sugars used in nutrition labelling and health claims standards in the Code and with international food composition database practice where total sugars has been defined as being only mono- and di-saccharides. It is also consistent with the definition of sugars used in the reporting of total sugars intake in the AHS. Honey, fruit juices and fruit juice concentrates were not included in this Standard and as such were not considered 'added sugars' under this definition.

Free sugars are defined by the WHO (2015) as:

"Free sugars include monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates".

Unlike the added sugars definition, this free sugars definition does include honey, fruit juices and fruit juice concentrates and is thus the point of difference between the two definitions. The only forms of sugar not included in the WHO definition of free sugars are intrinsic sugars and milk sugars. Intrinsic sugars are defined by the WHO as the sugars incorporated in the structure of intact fruit and vegetables. Milk sugars are the natural sugars present in milk (WHO 2015).

The definitions and how they fit together for this analysis are depicted in Figure 1.

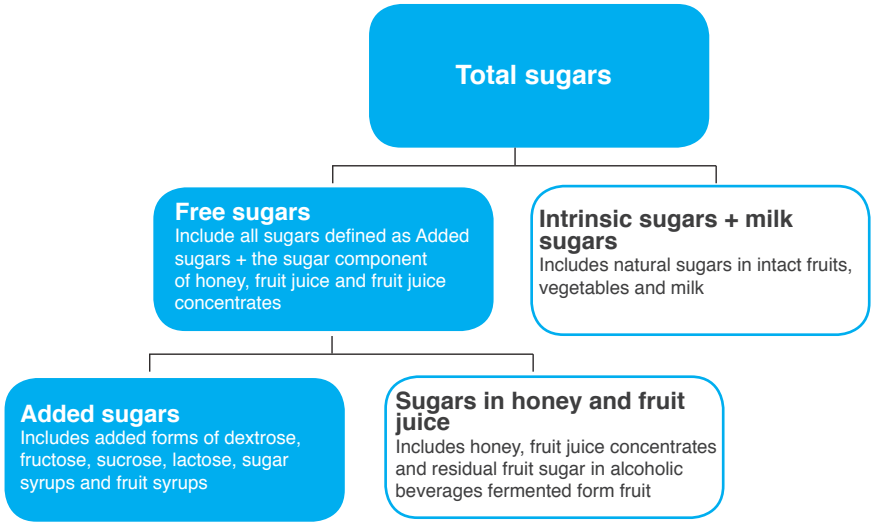

Figure 1: Relationship between total, added and free sugars (ABS 2016)

Developing the dataset

There were two main options for developing a dataset of 5,740 values for each of free and added sugars – food by food (manually) or by recipe calculation. This development step was also guided by the approach of Louie et al. (2015).

Developing values manually would mean taking a food such as strawberry milk and determining the portion of milk vs flavouring ingredients. This portion could then be applied to the total sugar value to determine the amount of added sugar. For example, if strawberry milk is 90% milk and 10% flavouring, and the total sugars for strawberry milk in AUSNUT = 9 g/100 g and for whole milk is 6 g/100 g, then the intrinsic sugars from milk are:

0.9 x 6.0 = 5.4 g/100 g

The amount of added sugars is then estimated as:

9.0 - 5.4 = 3.6 g/100 g.

This process is then repeated for each food in the dataset.

Developing values using a recipe approach is an expansion of this process. In this approach, values are allocated to 'ingredient' foods which contain only one form of sugar i.e. all added or all naturally occurring. These foods are then used as ingredients in recipes for foods with a mixture of added and naturally occurring sugar sources to calculate the proportion of each ingredient in the recipe; then the amount of added sugar that proportion represents; then to sum the added sugars from each ingredient to get the added sugars content for the food.

The decision was made to use a recipe approach. This allowed a more thorough assessment of the amount of added sugars. Although this method sounds complicated, the calculations were automated.

For ingredient foods, the total sugars content was allocated as follows:

» No sugars – foods with zero total sugars

» No added or free sugars - This differed slightly between the added sugars and free sugars datasets. Honey and fruit juice were assigned to the "No added sugars" category (for assessment of added sugars) and to "All free sugars" (for assessment of free sugars).

» All (100%) added or free sugars – foods where the only ingredients contributing to total sugars were one of the forms of Sugars as defined in Standard 1.1.2 of the Code (see above) (for assessment of added sugars) and honey and fruit juices (for assessment of free sugars).

All foods which had sugars from both natural and added sources, required a recipe to calculate the amount of added or free sugars.

FSANZ has an extensive existing recipe dataset used to assist with dietary exposure assessments and estimation of nutrient content. Many of these recipes needed to be customized for this project. For example, a recipe for plain cake may have been developed for nutrient estimation purposes using sugar as the only sweetening agent, and applied to all types of plain cakes regardless of whether or not the main sweetening agent was white sugar, honey or another ingredient. However, if this plain cake sometimes had honey as an ingredient, then for the added and free sugars analysis, the honey needs to be captured by the recipe.

Once the recipe dataset was finalized, the recipes were run through a set of calculations previously established for similar dietary intake assessments. They allowed for multiple layers of calculations (i.e. where a recipe is an ingredient in another recipe and so on, sometimes involving up to nine layers of calculation). The calculations included summation of multiple uses of added or free sugar ingredients in the same food, took into account any weight changes due to processing or cooking of ingredients and estimated the proportion of added or free sugars in the final food. The result of this process was a value (expressed in g/100 g) for added sugars and free sugars for each AUSNUT 2011-13 food.

Quality control steps

After the added and free sugars dataset was generated, a series of quality control steps were followed. The aim of this was to ensure the best possible values for those foods that contribute the most added sugars and/or that are ingredients in other foods. The previously published results of the National Nutrition and Physical Activity Survey (NNPAS) component of the AHS told us which foods contributed the most to sugar intakes across age and gender groups. FSANZ also knew from AUSNUT which foods contained the highest levels of sugars. If these categories were addressed and reviewed as a priority, then we could have a level of confidence that the foods that mattered the most to the outcome of the project were as accurate as possible.

The main data issue identified after the first round of data generation was that some foods had estimated added sugars contents that were higher than their analysed total sugars value, or appeared to be much lower than anticipated. For example, all of the added sugars values for pizzas were incorrect and this was found to be because of an error in the recipe for tomato paste. The tomato paste in AUSNUT was an analysed line with approximately 10% total sugar. The recipe developed for tomato paste, which involved de-hydrating fresh tomato using a large moisture loss, resulted in a total sugars value closer to 2%. A new ingredient food for pizza sauce was developed for use in these recipes which included sugar to approximate the analysed level. The pizza values derived by recipe all then corresponded very closely to the AUSNUT values.

In some cases, adjusting the underlying recipes would not result in an appropriate total sugars value due to differences in analysed versus recipe values. In these cases, the total sugars value was adjusted up or down to meet the AUSNUT total sugars value, with the added and free sugars being adjusted accordingly.

Results of the project

One in two Australians (52%) usually exceed the World Health Organization's recommendation that free sugars contribute to less than 10 per cent of total energy intake (ABS 2016). Beverages were the source of just over half of the free sugars, primarily from soft drinks, sports and energy drinks (providing 19 per cent of total free sugars), followed by fruit and vegetable juices (13 per cent of free sugars). The leading food sources of free sugars were muffins, cakes or scones and confectionary (each contributing 8.7 per cent), followed by free sugars in honey, jams (and similar spreads), ice confection and plain sugar.

Conclusions

It can be difficult to find the perfect balance between producing quality data and doing it in a timely manner. In designing a project such as this you need to identify the critical points that will influence overall quality and to focus on the foods that will have the greatest impact on the final estimated values. The time spent developing robust recipes was an investment in developing a resource that FSANZ can use for future similar projects without the need to re-estimate all values manually. Using a recipe approach meant that there would be a transparent dataset that can also be used by other groups. On the other hand, in order to meet time constraints, some loss of detail may have occurred for foods that are not major contributors to added and free sugars.

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Resolutions

The conference members developed the following resolutions at the meeting on 9 July 2016:

1. The OCEANIAFOODS community should use every opportunity to promote the importance of quality food composition data for public health purposes, including to address micronutrient deficiencies through the production of nutrient dense crops, and to address the growing problem of non-communicable diseases in the region. Promotion to national government and international organizations should happen at major Pacific Leaders' meetings such as regional forums and Codex Alimentarius regional meetings.

2. Closer links to the agriculture sector should also be developed to promote the relevance of nutritional quality of foods to this sector.

3. As an integral part of the preceding resolutions, another edition of the Pacific Islands Food Composition Tables should be developed, by identifying and compiling existing data that is relevant to the foods consumed across the Pacific and containing a wider range of nutrients than at present.

4. Opportunities for training Oceania's scientists in the area of food composition should be promoted wherever possible. As a first step, regional universities should be made aware of the existence of the FAO's free e-learning course, http://www.fao.org/infoods/infoods/training/en/

List of Delegates (Course and/or Conference)

First name	Surname	Country	Address	Contact email
Paul	Adorno	Australia	National Measurement Institute, Port Melbourne, Melbourne	paul.adorno@measurement.gov.au
Jayashree	Arcot	Australia	Co-Director, ARC Training Centre for Advanced Technologies in Food Manufacture, UNSW Australia	j.arcot@unsw.edu.au
Paul	Armishaw	Australia	National Measurement Institute, North Ryde, Sydney	Paul.armishaw@measurement.gov.au
Danielle	Ballantyne	Australia	Food Standards Australia New Zealand, Canberra, Australia	Danielle.ballantyne@foodstandards.gov.au
Isabel	Castanheira	Portugal	EuroFIR	isabel.castanheira2@gmail.com
Maria Veronica	Chandra-Hioe	Australia	Researcher, UNSW Australia	m.v.chandra-hioe@unsw.edu.au
Coral	Colyer	Australia	Goodman Fielder Ltd.	Coral.Colyer@goodmanfielder.com.au
Judy	Cunningham	Australia	Consultant	Judyc121@gmail.com
Shirin	Dabestani	Australia	PhD student, UNSW, Australia	s.dabestani@unsw.edu.au
Lazarus	Dawa	Papua New Guinea	Department of Health, Port Moresby, PNG	Lazarus.Dawa@gmail.com
Faradilla	Fitri	Indonesia	PhD student, ARC Training Centre for Advanced Technologies in Food Manufacture, UNSW Australia	r.faradilla@unswalumni.com
Elizabeth	Fleming	New Zealand	University of Otago, New Zealand	liz.fleming@otago.ac.nz
Heather	Greenfield	Australia	UNSW, Australia	h.greenfield@unsw.edu.au
Brynn	Hibbert	Australia	School of Chemistry, UNSW, Sydney	b.hibbert@unsw.edu.au
Tien Dat	Huynh	Vietnam	PhD student, UNSW Australia	Tien.huynh@unswalumni.com
Suganya	Jeyaprakash	India	PhD student, UNSW Australia	s.jeyaprakash@student.unsw.edu.au
Zione	Kalumikiza	Malawi	Lilongwe University of Agriculture and Natural Resources (Bunda College), Lilongwe, Malawi	kalumikizaz@gmail.com
Jimaima	Lako	Fiji	Fiji National University, Fiji	lakojimaima@gmail.com
Janet	Lipai	PNG	National Agricultural Research Institute, P.O. Box 8277 Boroko, N.C.D. Papua New Guinea	Janet.lipai@nari.org.pg
Shi	Liu	China	Student, UNSW Australia	N/A
Glen	Maberly	Australia	Westmead Hospital, Sydney	Glen.Maberly@yahoo.com
Scott	Markham	Australia	PhD student, UNSW Australia	Scott.markham@student.unsw.edu.au

Karen	Mejos	The Philippines	PhD student, UNSW Australia	karenmejos@yahoo.com
Tony	Ng	Australia	Xyris Software Australia Pty Ltd, Brisbane, Queensland, Australia	tony@xyris.com.au
Minh Anh Thu	Phan	Vietnam	PhD student, UNSW Australia	minhanhthu.phan@unsw.edu.au
Kim-Yen	Phan-Thien	Australia	School of Life and Environmental Sciences, University of Sydney	kim-yen.phan-thien@sydney.edu.au
Alia	Rahmi	Indonesia	Faculty of Agriculture, Lambung Mangkurat University, Jl. Jend. A. Yani Km 36.5 Banjarbaru 70714, Indonesia	Alia.rahmi@gmail.com
Anna	Rangan	Australia	University of Sydney, Sydney	Anna.Rangan@sydney.edu.au
Adel	Rezaeimotlagh	Australia	PhD student, UNSW Australia	N/A
Bithika	Saha	Australia	PhD student, UNSW, Australia	bithika.saha@unsw.edu.au
Siva	Sivakumaran	New Zealand	Plant and Food Research, Palmerston North, New Zealand	siva.sivakumaran@plantandfood.co.nz
Subathira	Sivakumaran	New Zealand	Plant and Food Research, New Zealand	Subathira.sivakumaran@plantandfood.co.nz
Tina	Soaki	Vanuatu	Ministry of Tourism, Trade, Commerce and Business, PMB, 9056, Vanuatu	tsoaki@vanuatu.gov.vu
Renee	Sobolewski	Australia	Food Standards Australia and New Zealand, Canberra, Australia	Renee.Sobolewski@foodstandards.gov.au
Ji	Song	Australia	PhD student, UNSW Australia	N/A
Lewis	Taku	Papua New Guinea	National Agricultural Research Institute, P.O. Box 8277 Boroko, N.C.D. Papua New Guinea	takumumbo@gmail.com
Shari	Tompsett	Australia	FSANZ	Shari.tompsett@foodstandards.gov.au
Fatma	Bahwan Al Mukhaini	Qatar	Masters student, UNSW, Australia	N/A
Dayna	Berry	Australia	Undergraduate student, UNSW Australia	z5015131@zmail.unsw.edu.au
Katherine	Gajo	Australia	Undergraduate student, UNSW, Australia	z5035771@unsw.edu.au
Chatchaporn	Uraipong	Australia	PhD student, UNSW Australia	c.uraipong@unsw.edu.au