Australasian Medical Journal 2010, 1, 1, 97-112

THE NUTRITION SOCIETY OF AUSTRALIA (INC.)

Thirty-Third Annual Scientific Meeting
Joint Annual Scientific Meeting of the Nutrition Society of Australia & the Nutrition Society of New Zealand
Newcastle, Australia, 8 - 11 December 2009

Friday 11th December 2009

Plenary Session 5: Structuring Food for Health

Please cite this paper as: Conference Abstracts Nutrition Society of Australia and Nutrition Society of New Zealand 2009: IV. AMJ 2010, 1, 1, 28-45. Doi 10.4066/AMJ.2010.208

Structuring food materials to control nutrient bioavailability

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Since the early 20th century, the science of nutrition has created an important knowledge base of the vitamins, minerals, amino acids and fatty acids that are essential to human health. The foods we eat are composed of some or all of these elements, and it is now being belatedly recognized that the matrix in which they are presented has an impact on their availability at the point of utilization in the body. As well as possessing a natural structure imparted by its source e.g. as meat muscle, fruit or vegetable, the majority of the food we eat is processed in some way and this can destroy, impose or refashion that structure. Traditionally, food processing treatments are applied to destroy pathogenic organisms, to preserve the nutritive qualities and to optimise the textural and sensorial traits, which also depend on the architecture of the food matrix.

From the perspective of essential nutrients (vitamins, minerals, essential amino acids and fatty acids), the processed foods are designed to ensure the maximum bioavailability – the greater the bioavailability, the better the nutrient. Food matrices that compromise rapid absorption are considered deleterious and are deliberately destroyed by processing. However, new scientific findings have begun to unravel the importance of the complex food structures in the dynamics and delivery of nutrient molecules. For example, one of the simplest food molecules, glucose, is now recognised to exert very different health consequences if delivered quickly as opposed to slowly.

As a consequence we need to see food product development in a broader context. The conception and design of new products could consider making use of food structures that may provide "kinetic" effect on nutrient bioavailability – i.e. reducing it, sustaining it or increasing it.

There are niche opportunities for food products with particular properties which will provide selectable benefits, but tackling the major food-linked health issues of obesity, cancer and cardiovascular diseases requires greater knowledge and understanding of how the digestive system treats, transports and utilizes the major food components, minerals, proteins, carbohydrates and lipids.

This presentation will discuss relevant information on how the dynamics of nutrient uptake is influenced by food structure and composition, e.g. microstructural features, such as particle size and shape, self-assembled structures and molecular structures.

Describing dietary energy – do we need a new approach?

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It is customary to calculate the metabolisable energy (ME) content of foods based on Atwater[1] or similar general factors. Such an approach assumes that the ME of a food can be accurately predicted based on three chemical components (crude protein, fat, carbohydrate) and that the ME of each component does not vary greatly across diverse foods. Implicit in this assumption is that the ME content of a food is affected by the fat, carbohydrate and protein contents only; that the ratio of gross energy (heat of combustion) to either fat, protein or carbohydrate is constant across foods, that differences among foods and food ingredients in the degree of digestibility of each of fat, carbohydrate and protein are quantitatively unimportant, that differences in the urinary excretion of energy per unit dietary protein are quantitatively unimportant and that interactive effects among dietary components on nutrient assimilation can be ignored. The literature is replete with empirical evidence demonstrating that the latter assumptions are untenable. Further, these factorial based ME systems do not account for what are quite pronounced differences in the biochemical efficiencies of utilisation of absorbed nutrients.

Whereas the Atwater or similar factorially-based ME systems may be sufficiently accurate (though this is by no means certain) for describing dietary energy for purposes of general dietary labelling, they are inaccurate for describing the available energy content of specifically formulated weight-loss foods. The inclusion of such foods in the diet is an important strategy for combating obesity in humans, and the available calorific values of such foods need to be known with a high degree of accuracy.

Human metabolism studies[2] conducted at our centre, for adult subjects (n=27) given either a high-fat low fibre diet (refined diet), a low-fat high-fibre fruit and vegetable based diet or a low-fat high-fibre cereal based diet demonstrate significant ($P< 0.05$) differences between ME calculated based on Atwater or similar factors and determined ME values. Differences of up to 4% for the refined diet and up to 11% for the low-fat high-fibre diets were found. Such differences highlight the inaccuracy of the factorial systems for predicting ME, especially in weight-loss foods and diets specifically formulated to have lower 'available' energy contents, whereby even small differences in ME are likely to be of practical significance.

To address the inherent inaccuracy in ascribing constant factors to foods and food ingredients to estimate ME content, we have developed an *in vivo/in vitro* digestion model to allow relatively rapid flexible prediction of ME in foods. The approach is based on an *in vivo* (growing rat or pig) model of upper tract (mouth to ileum) food digestion and an *in vitro* hindgut digestibility assay which utilises a human faecal innoculum and provides estimates of the fermentability (and thus short chain fatty acid production) of undigested material entering the colon from the small bowel. The *in vivo/in vitro* model system has been used to predict total tract organic matter digestibility (OMD, %) in humans for a wide range of diets and compared with determined values for the diets given to human subjects in a metabolism study (L Coles and PJ Moughan, unpublished data). Close agreement (predicted versus actual) has been established, supporting the validity of the model (wheat bran diet, predicted OMD = 92.3, actual OMD = 93.5; Pectin diet, predicted OMD = 96.9, actual OMD = 96.9; low fibre diet, predicted OMD = 94.8, actual OMD = 96.7; high fibre diet, predicted OMD = 91.5, actual OMD = 92.8; fruit and vegetable diet, predicted OMD = 91.4, actual OMD = 92.3; cereal diet, predicted OMD = 89.6, actual OMD = 90.0).

Our validated predictive model is further enhanced by incorporating a mathematical simulation of the catabolism of absorbed nutrients and the energy costs incurred in hindgut microbial fermentative processes, based on the stoichiometry of oxidative pathways, which are known with accuracy. The overall combined model (*in vivo/in vitro* assays and mathematical simulation) can be applied to allow the prediction of 'available' as opposed to 'metabolisable' energy of foods, and gives a prediction of the ATP generated from a food, during the oxidative state (the state pertaining to body weight loss). The ATP energy (physiological energy) value of a food allows for a true energetic ranking of foods in terms of their value for sustaining body weight loss. The simulation of the biochemical efficiency of utilisation of absorbed nutrients is an important step to take into account as there are significant differences among nutrients in efficiency of utilisation. Protein and fibre are utilised for ATP production some 35 to 40% less efficiently than glucose and fatty acids.

The predictive model has been applied to foods. For a whole food (green kiwifruit) metabolisable energy (ME) was calculated (Atwater modified) to be 14 kJ/gDM and available energy (ATP) as 6.42 kJ/gDM. The predicted values were compared with dextrin as a baseline (where it was assumed that all carbohydrate was absorbed and metabolised as glucose). The ratio kiwifruit:dextrin for ME was 0.84 while the comparable ratio for available energy was 0.63. The ATP available energy measure demonstrates that kiwifruit provides considerably less energy compared to the dextrin baseline, than what would be concluded based on the ME system. Such differences are of great practical significance. Comparable ratios for a proprietary weight loss food sold on the Australasian market were 0.9 and 0.68, again demonstrating important differences in the rankings of the foods. The combined model can be applied in the development of specific weight-loss food products and diets.

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Particle size effects on satiety and digestibility in food and feed

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Background

The particle size of human food and animal feed is expected to impact on both mechanical properties and access of digestive enzymes during gastro-intestinal passage. This could lead to effects on perceived satiety as well as on rates of uptake of nutrients. Only limited work has been reported on the effect of the architecture of iso-compositional foods on perceived satiety (1,2). Similarly, although it is understood that particle size affects digestibility of e.g. starch (3), and that *in vitro* digestion rates correlate with *in vivo* digestion rate and extent (4), the underlying mechanisms have not been defined quantitatively.

Objectives

1. To define the effect of food architecture on perceived satiety for breakfast meals based on each of beef, oatmeal, or mixed fruits. 2. To identify the physical or biochemical basis for observed satiety effects through *in vitro* measurement of rheological and enzyme digestion /

nutrient release properties. 3. To characterize the effect of particle size on *in vitro* starch digestibility for ground sorghum and barley grains. 4. To identify mechanisms controlling the rate of starch digestion in ground grains.

Design

1. Healthy volunteers (n=29) were served 1000 kJ breakfast meals based on one of beef (steak, mince, sausage), rolled oats (whole or ground) and milk, or mixed fruits (pieces, chopped, pureed), in a within-subject design. Satiety was rated at regular intervals over a 3 hour time period using a labeled magnitude scale (5). 2. Volunteers (n=3-6) chewed each of the breakfast meals until ready to swallow, then spat out. The rheological properties of all spat samples were evaluated in a Rapid Visco Analyzer under simulated gastric conditions. Relevant nutrient release profiles from spat samples were monitored under simulated gastric and small intestinal conditions i.e. protein hydrolysis (6) for beef, starch hydrolysis (7) for oats, and sugar release for fruits. 3. Sorghum and barley grains were hammer milled through a 4 mm screen, and subsequently fractionated by capture on a series of sieves ranging from 2.8 mm to 0.125 mm. The digestibility of starch in each fraction was monitored over time under simulated gastro-intestinal conditions (8). 4. Starch digestion rates were fitted using first order kinetics (3) and effects of particle size on rate coefficients quantified.

Outcomes

1. Significant differences in perceived satiety between meals with different food architectures were found for rolled oats (whole > ground) and to a lesser extent mixed fruits (pieces > chopped > pureed), but not for beef. 2. Intact foods (beef steak, whole oats, mixed fruit pieces) had higher viscosity than other 'chew and spit' samples. Nutrient release kinetics were similar for each of the foods of a given type. 3. Starch digestion followed first order kinetics for all grain particle size fractions. For particle sizes above 0.25 mm (for barley) or 0.125 mm (for sorghum), rate coefficients showed an inverse square relationship with particle size.

Conclusion

Food architecture can play a significant role in determining satiety, at least for plant-based foods. Where food architecture is digested directly (beef), similar proteolytic degradation rates may be the reason for similar satiety ratings. Where food architecture is due to indigestible cell wall components (oats, fruit), rheological properties rather than carbohydrate nutrient release rates may be the origin for satiety differences. Although starch in hydrated grain components (e.g. rolled oats in milk) is digested independent of particle size, this is not the case for condensed forms such as in milled raw grain. The inverse square relationship between starch digestibility and particle size suggests that enzyme diffusion is the rate-determining step for milled grains above a lower limit that is similar to endosperm cell size.

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Homeostasis and the accuracy of functional food values

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Background

The health benefits of foods are not usually due to the action of individual food components, but are effects of the food as a whole, and are mediated by biochemical and physiological changes in response to consuming the foods. Therefore, assessment of the functional efficacy of a food, and communication of it, requires the use of specific biochemical /physiological changes – biomarkers – linked to health end points, rather than values for real food components. And when such changes are expressed relative to the effect of a reference food or material the effect is expressed as weight equivalents of the reference. Thus the biomarker may become the basis of a virtual food component (VFC) with weight units that can be used in much the same way as nutrient, and the two sets of values may be used conjointly to say not only what a food is, but also, what it does[1].

The most practical way to use VFCs in dietary management of disease risk would be to treat them as a linear function of food intake, and to simply add the VFC values of different foods to determine a meal value. However, as biomarkers are physiological changes they will be subject to homeostasis, so will not be a linear function of food intake. It is important to know how much this non-linearity affects both the accuracy with which VFC values are determined, and the accuracy with which they may be applied. We have examined the effect of homeostasis on measurement and use of the VFC glycaemic glucose equivalent (GGE), defined

as the weight of glucose that would induce the same blood glucose response as a specified quantity of food, and summarize the results here.

Objective

To develop a procedure for the accurate determination of the relative glycaemic impact of customarily consumed portions of foods and meals, firstly by allowing for different homeostatic responses to the various quantities in customarily consumed portions of foods during GGE measurement, and secondly, by accounting for the error that develops when GGE values for a meal are obtained by linear summation of GGE values for individual foods without allowing for the quadratic glucose dose-glycaemic response relationship that is a result of homeostasis.

Design

Rates of apparent blood glucose clearance were determined from blood glucose response curves of 20 subjects consuming five foods at three intakes[2]. The timed release of glycaemic carbohydrate during digestion of customarily consumed portions of the foods was also determined by *in vitro* digestion. From the difference between cumulative carbohydrate release, and apparent blood glucose clearance, values for net GGE as a function of time were calculated. From the area under the curves of netGGE versus time the homeostasis-adjusted GGE content of the food portion was calculated by comparing with the area for a white bread reference. GGE values based on a range of different glucose reference doses were also added to obtain meal GGEvalues, and the values compared with values calculated from the quadratic glucose dose-glycaemic response, to determine theoretical limits between which GGE values may be added without excessive accumulation of error, and how it is affected by the glucose reference on which GGE is based.

Outcomes

Net GGE plotted against time gave curves reminiscent of blood glucose response curves. The correlation between the *in vivo* values of GGE calculated from GI values for the same foods and *in vitro* values was: In vivo GGE = 0.96 in vitro GGE - 0.31; R^2 = 0.9013. Bland Altman analysis showed close agreement between the methods: y = -0.009x + 0.96; R^2 = 0.0008. Theoretical analysis showed that calculation of meal GGEs by linear summation of GGE values of individual foods could lead to inaccurate (>5 g) estimates of the GGE content of meals, with the inaccuracy depending on the GGE total, the number of foods, and the size of the glucose reference on which the glucose equivalence in GGE was based. A glucose reference of 30-40 g for the determination of GGE gave the least error.

Conclusion

The relative glycemic impact of customarily consumed food portions may be accurately determined by *in vitro* digestive analysis that takes in account homeostatic, dose-dependent, blood-glucose clearance. However, the intrinsic non-linearity of the glucose dose-blood glucose response relationship imposes limits on the linear summation of VFCs representing glycemic impact, requiring caution in dietary management and epidemiological interpretation. The results have shown that the effects of homeostasis may need to be considered when using food values based on the efficacy of functional foods as guides to food choice.

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Concurrent Session 16: Cognition

Please cite this paper as: Conference Abstracts Nutrition Society of Australia and Nutrition Society of New Zealand 2009: IV. AMJ 2010, 1, 1, 28-45. Doi 10.4066/AMJ.2010.208

Childhood behaviour and learning disorders respond to changes in erythrocyte polyunsaturated fatty acid content

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Background

Previous studies indicate that supplementation with omega-3 polyunsaturated fatty acids (n-3 PUFA) may improve symptoms in children with ADHD and learning difficulties. However, the relative benefits of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) supplementation are unknown.

Objective

To compare effects of supplementation with DHA-rich and EPA-rich oils versus safflower oil on cognition and behaviour in children with ADHD symptoms and learning difficulties.

Design

Ninety children were recruited for a 12-month double-blind placebo-controlled three-way crossover trial. Supplements high in EPA (1000 mg EPA + 120 mg DHA/day), DHA (240 mg EPA + 1000 mg DHA/day) and n-6 PUFA (safflower oil) were each consumed in random order for four months. Erythrocyte PUFA status, assessments of attention, cognition and literacy and Conner's Parent Rating Scales (CPRS) were measured at 0, 4, 8 and 12 months. Outcomes from the initial 4 month parallel comparison are considered herein.

Outcomes

Fifty four volunteers completed the trial. There were no differences in responses to the supplements in the first 4 months. However, in 45 children with erythrocyte PUFA data, increases in DHA content were associated with improved CPRS scores on oppositional behaviour (r=.38, p<.05), anxiety/shyness (r=.33, p<.05), divided attention (r=.32, p<.05) and reading (r=.50, p<.01). Unexpectedly, improved ADHD index scores (r=.32, p<.05) correlated with increased n-6 PUFA. In a subgroup with learning difficulties (n=16), increased DHA was associated with improved oppositional behaviour (r=.78, p<.01), hyperactivity (r=.70, p<.01), restlessness/impulsivity (r=.71, p<.01), divided attention (r=.71, p<.01), word reading (r=.67, p<.01) and spelling (r=.56, p<.01).

Conclusion

DHA consumption may improve ADHD symptoms and literacy in children with learning difficulties.

Participation in a dietary intervention study improves mood in postmenopausal women

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Background

Dietary therapies are routinely recommended to reduce disease risk; however, there is concern they may adversely affect mood and psychological wellbeing as they can be burdensome and restrictive.

Objective

To determine if there were any effects on mood of a vitality diet (VD) (low-sodium DASH-type diet including red meat compared to a reference healthy diet (RHD) (based on general dietary guidelines to reduce fat intake and increase intake of breads and cereals).

Design

In a randomised, parallel-design dietary intervention study, women aged 45-75 years were assigned to either the VD or RHD for 14 weeks. Mood was measured fortnightly by the Profile of Mood States (POMS), including 2 weeks prior to commencement of the diet. Differences in mood between baseline and the 14 week study for the VD or RHD were assessed with the Friedman test for repeated measures (to adjust for multiple comparisons, P<0.01 was considered to be statistically significant).

Outcomes

Of the 111 women commencing the study, 36 completed the POMS at all time points for the VD and 39 completed the POMS at all time points for the RHD. The mean (SD) age was 59.3 (5.1) yr and the mean BMI was 29.7 (4.4) kg/m^2. For the VD diet, a significant improvement was observed over the 14 week study for POMS ratings for tension, depression, anger, fatigue and confusion (P < 0.01 for all), but not vigour (P≥0.05). For the RHD diet, a significant improvement was observed for tension, anger and confusion (P<0.01 for all), but not depression, fatigue or vigour (P≥0.01). There was no significant difference in the change in mood (week 14 – baseline) between the VD and RHD groups (P≥0.01).

Conclusion

Dietary patterns that can potentially reduce disease risk do not seem to have a deleterious effect on mood. Both dietary patterns, including a low-sodium DASH type diet including red meat consumption on most days and a reference healthy diet, appear to have an overall positive effect on mood state, although it is difficult to determine if this was due to a generalised positive response from participating in a study or due to dietary components within

each diet. This research was supported by Meat & Livestock Australia.

What contributes to weight loss dietary adherence? Results of a psychosocial investigation

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Background

The burden from chronic disease resulting from overweight has appreciably risen in Australia. Weight reduction can give substantial benefits in preventing and treating chronic disease. These only occur when weight loss is achieved and maintained. Low dietary adherence prevents this occurring. Self determination theory (SDT) has shown relationships to health behaviour change and may be useful for investigating dietary adherence.

Objective

To investigate how qualitative and quantitative findings converge and inform about dietary adherence and how this changes over time, using SDT, in a 12 month weight loss trial.

Design

A mixed methods (QUAL- quan) concurrent transformative design was used with SDT as the guiding theoretical framework. Two semi-structured interviews were conducted with a subsample of trial participants between one to three months (n=14) and nine to 12 months (n=13). These were thematically analysed. SDT questionnaires were completed (n=30) at baseline, one, three and six months and analysed with partial least squares.

Outcomes

A number of psychosocial factors improved adherence. At a personal level, being focused on intrinsically motivated goals, including those of improving health and family, were important. Individual themes of 'being conscious', 'keeping positive' and 'ownership of the meal plan' were present. These became stronger over time for higher adherers. In terms of social support, praise and non-criticism were important. In the trial, regular nutritionist appointments, along with encouragement and positivity within consultations, positively influenced adherence. Adoption of exercise in the trial also encouraged higher dietary adherence. With lower adherence, participants were focused on extrinsically motivated goals, and personal themes of 'blame' and 'getting down on yourself' were prominent. These findings were confirmed by questionnaire results.

Conclusion

Dietary adherence can change over time and some psychosocial factors are potentially modifiable to impact upon this. For practitioners, consultations could be used to focus on intrinsically motivated goals, attributes of monitoring and positive reframing techniques that may improve dietary adherence.

Associations between mild to moderate depression and food intake patterns in overweight subjects participating in a diet and physical activity intervention

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Background

There are strong and consistent relationships between depression and obesity, physical activity and energy intake in various gender/age categories. Conversely, obesity and coronary heart disease both correlate with an elevated risk of depression, which in turn is also associated with increased risk of developing type II diabetes. Depression therefore has the potential to affect cardiometabolic risk through multiple pathways

Objective

The present study sought to investigate the potential role of depression in the conduct of a diet-based weight loss trial, particularly in relation to associations with dietary (food group) intake patterns.

Design

Forty four overweight (BMI >27), otherwise healthy subjects, were recruited and randomized to follow their usual diet or an iso-caloric diet in which saturated fat was replaced with monounsaturated fat (~20%), via macadamia nuts. Subjects were assessed for depressive symptoms (BDI-II) and dietary intake at baseline and 10 weeks.

Outcomes

Baseline analysis showed that depression scores were negatively correlated to vegetable (p=0.05) and positively to "Extras" (p=0.05) food group intake. Secondly, cereal food group intake changes in response to the intervention was influenced by baseline BDI (P=0.02). Increases in depression scores from baseline to week 10 associated with decreased fruit intake over the intervention period (r=-0.66, p=0.01). No association was observed between randomisation to dietary group and changes in depression scores.

Conclusion

Mild to moderate depression scores may associate with specific dietary patterns and interfere with the capacity for dietary change in overweight individuals. Dietary interventions tailored to depression status or having depression scores minimised prior to dietary intervention may be useful strategies to improve sustained weight loss in overweight individuals.

Erythrocyte polyunsaturated fatty acid status, memory and cognition in older adults with mild cognitive impairment and healthy controls

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Background

Blood polyunsaturated fatty acid (PUFA) status is reportedly altered in older adults with cognitive decline and in those with depression compared to healthy controls. Depression is associated with the onset of cognitive decline and progression from mild cognitive impairment (MCI) to dementia.

Objective

To compare cognition, memory and mood with omega-3 (n-3) and omega-6 (n-6) PUFA status (as indicated by erythrocyte PUFA levels), in an elderly population with MCI and in healthy controls.

Design

Volunteers ≥ 65 yrs with MCI (n=38, Paired Associate Learning score 2 SDs below the mean and/or Demtect score 9-12) and healthy controls (n=29) were tested for memory function, cognition, and depressive symptoms using a questionnaire. Erythrocyte PUFAs (% of total fatty acids) were measured in fasted blood samples.

Outcomes

Erythrocyte eicosapentaenoic acid (EPA) was lower in those with MCI (0.98%) compared with controls (1.2%, P<0.05); docosapentaenoic acid (DPA) n-6 was higher in those with MCI (0.38%) compared with controls (0.34%, P<0.01). There were no other differences in PUFA between MCI and controls. There were several significant correlations between PUFA and cognitive function: arachidonic acid (n-6) was associated with worse performance on the Stroop (r=0.256 P<0.05), Digits Backward (r=-0.357 P<0.01), and Trail Making (r=0.303 P<0.05) tests, EPA was associated with better performance on Excluded Letter Fluency (r=0.288 P<0.05) and DPA n-3 was associated with better performance on the Boston Naming Task (r=0.255 P<0.05). Those with MCI had higher scores on the Geriatric Depression Scale (MCI=3.13 controls=1.40, P<0.01). Depression scores were associated with poorer performance in cognitive tests, including the Rey Auditory Verbal Learning Test (r=-0.408 P<0.001) and letter number sequencing (r=-0.311 P<0.05).

Conclusion

Lower n-3 PUFA status, higher n-6 PUFA status and depressive symptoms may contribute to cognitive deficits and memory problems in older adults.

Associations between Omega-3 polyunsaturated fatty acids, APOE-ε4 allele status, and cognitive functioning in an older community-dwelling sample

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Background

The omega-3 (*n*-3) long-chain polyunsaturated fatty acids (PUFA) eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are important for normal brain functioning. Evidence in human studies suggests a link between *n*-3 PUFA and cognition in ageing; lower plasma and erythrocyte levels of *n*-3 have been associated with the presence and greater risk of dementia, cognitive decline, and lower cognitive function in older age. Apolipoprotein E (ApoE) plays a role in lipid metabolism and carriage of ApoE-ε4 allele is a risk factor for cognitive decline. ApoE-ε4 carriers have shown differential responses to fish-oil and differential relationships between cognitive functioning and measures of *n*-3.

Objective

To examine relationships between erythrocyte membrane levels of *n*-3 PUFAs, cognitive functioning, and APOE-ε4 status in a sample of cognitively-healthy older participants (MMSE > 23).

Design

Results are from the baseline data of the EPOCH (older people, omega-3, and cognitive health) trial: An 18-month parallel, randomised, double-blind, placebo-controlled trial examining the effect of fish-oil (DHA-rich) on age-related cognitive decline. Participants were 391 (46.3% male) community-dwelling adults, aged 65-90 years (M = 73.1, SD = 5.5). The cognitive constructs assessed were: working memory, reasoning, short-term memory, long-term memory and retrieval, speed of reasoning, inhibition, perceptual speed. Erythrocyte membrane levels of n-3 fatty acids were measured and APOE genotype was assessed.

Outcomes

Multiple regression was used to examine relationships between erythrocyte membrane levels of *n*-3 PUFA and the cognitive constructs, controlling for possible confounding factors. Interaction terms were included for each *n*-3 PUFA variable with APOE-ε4 status. In separate models, interactions between APOE-ε4 status and EPA (β=.170, p=.049), *n*-3 index (β=.142, p=.019), and total *n*-3 (β=.125, p=.038) predicted speed of reasoning scores.

Conclusion

Results suggest that EPA is positively related to some aspects of cognitive functioning and that this relationship is moderated by carriage of the APOE- ε4 allele.

Concurrent Session 17: Paediatric Nutrition

Please cite this paper as: Conference Abstracts Nutrition Society of Australia and Nutrition Society of New Zealand 2009: IV. AMJ 2010, 1, 1, 28-45. Doi 10.4066/AMJ.2010.208

The polyunsaturated fatty acid intakes of children from the Kids Eat Kids Play Survey

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Background

The Kids Eat Kids Play survey is the first national survey of Australian children's nutrition since 1995 and the first national physical activity survey since 1985. The National Health & Medical Research Council (NHMRC) Nutrient Reference Values recommend Adequate Intakes (AI) for linoleic acid (LA), alpha-linolenic acid (ALA) and long chain omega-3 polyunsaturated fatty acids (LC n-3 PUFA) ranging from 5-12 g/day, 0.5-1.2 g/day and 40-125 mg/day respectively, depending on age and gender. The NHMRC also recommend Suggested Dietary Targets (SDT) for optimising diets for lowering chronic disease risk and the SDT for LC n-3 PUFA is 500 mg/day.

Objective

To determine the current PUFA intakes, including the LC n-3 PUFA, with comparison to AI and SDT and to determine potential differences in intakes between children of different body weight and physical activity levels.

Design

The demographic and nutrient data files were merged for 4834 children aged 2-16 years.

Outcomes

The mean (median) PUFA intakes for 2-3 yrs, 4-8 yrs, 9-13 yrs, 14-16 yrs are as follows: linoleic acid (g) 5.2 (4.3), 6.7 (5.7), 8.3 (6.9), 9.7 (8.3) respectively; alpha-linolenic acid (g) 0.85 (0.71), 1.03 (0.86), 1.16 (0.99), 1.36 (1.17) respectively; LC n-3 PUFA (mg) 116 (47), 124 (55), 168 (67), 168 (78) respectively.

Children met the AI for linoleic acid and alpha-linolenic acid, but only approximately 50% of children met the AI for LC n-3 PUFA. Furthermore, only 7% of the children met the SDT of 500mg LC n-3 PUFA per day for each of the age groups, accounting for total energy intake. Comparison of LC n-3 PUFA tertile intakes showed no differences in 1) LC n-3 PUFA intakes in underweight, normal weight, overweight and obese children and 2) mean physical activity levels.

Conclusion

The majority of children need to increase their LC n-3 PUFA intakes to meet the SDT.

Soft drink consumption among Australian children

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Background

A high intake of sugary drinks contributes to obesity and other adverse health outcomes such as type 2 diabetes, metabolic syndrome, dental caries, and osteoporosis. Soft drinks, or sugar-sweetened carbonated beverages, are the most popular sugary drinks in Australia. Although they are identified as an 'extra' food in the Australian Guide to Healthy Eating, they are consumed in large quantities by a significant portion of the population.

Objective

To examine the soft drink consumption patterns of Australian children using the National Nutrition Survey 1995 and the more recent 2007 Children's Survey.

Design

Sugar-sweetened soft drink consumption patterns were analysed by age and gender using one day 24-h recall data from the NNS 1995 (children aged 2-18 yr) and the 2007 Children's Survey (children aged 2-16 yr).

Outcomes

The NNS 1995 found that about a quarter of 2-7 yr olds, a third of 8-15 yr olds and half of 16-18 yr olds consumed soft drinks. Boys tended to consume more soft drink than girls, with boys aged 16-18 yr drinking an average of 480 mL per day (or 840 mL per day among those who consumed soft drink), double the consumption of girls that age. The more recent Children's Survey found similar results, with a third of 8-15 yr olds and 40% of 16 yr olds consuming soft drinks, although the proportion of 2-7 yr old consumers was lower (at 14%). Boys aged 12-16 yr were the highest consumers (17-18 yr old children were not included in this survey) with an average intake of 240 mL per day, or 580 mL per consumer per day. Per capita consumption of soft drinks was somewhat lower in the Children's Survey compared to the previous national survey. Direct comparisons between the surveys are limited due to differences in sampling frame, age groups, and collection of dietary data.

Conclusion

Soft drinks are consumed in excessive amounts by Australian children. Although the level of intake may be moderating, public health interventions to further reduce consumption are needed.

The dietary patterns and intake of healthy New Zealand preschool children

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Background

We have limited knowledge of the nutritional status of preschool aged children in New Zealand, the 2002 Children's Nutrition Survey only surveyed children aged 5-14 years. The studies that have been reported in New Zealand preschool children are mainly in Dunedin and Auckland and often are in hospitalised or unwell children. With increasing nutrition knowledge we are now aware that the dietary intake we have as a preschooler is important for current and future health, and poor nutrition at this age is a risk factor for many conditions including obesity, heart disease, and diabetes.

Objective

The objective of this study was to describe the dietary patterns and intake of healthy Auckland preschool children aged less than five years of age.

Design

Three hundred and forty nine healthy children from Central and West Auckland, New Zealand and their caregivers were interviewed to establish normal dietary intake. A number of measurements were recorded. This data was analysed and compared to the Ministry of Health dietary guidelines for this age group.

Outcomes

Most children were breast fed initially, although this tended to drop over time. While dietary iron intake is fine from 0-6 months of age, it is a concern from 7 months and this continues for the rest of the preschool years. Calcium, Zinc and Vitamin A intakes in this group were not of concern. In the children over 2 years of age most children met the recommended intake of meats or alternatives (93%), however the percentage meeting the food and nutrition guidelines was limited for breads and cereals (11%), and lower for vegetables (54%), dairy and alternatives (64%) and fruit (66%). There are no guidelines in New Zealand for children under the age of 2 years.

Conclusion

This study suggests that preschool children in Auckland, New Zealand have dietary patterns that may not provide them with adequate nutrients to support healthy growth and development and may result in disease in later life.

Does a school garden program have a differential impact on vegetable intakes in boys versus girls attending primary school?

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Background

Australian children are not meeting national recommendations for fruit and vegetable intakes which increases the risk of future chronic diseases. Food preferences in childhood are a key indicator of usual intake with boys shown to have a lower preference for fruit and vegetables compared to girls. The school environment is as an ideal setting in which to promote healthy eating, with school gardens one strategy to try and increase preferences and thus intake of fruit and vegetables. However to date this approach has rarely been evaluated.

Objective

To determine whether participation in a school garden program produces differential increases in total fruit and vegetable intake between boys and girls.

Design

A quasi-experimental pilot study of 127 children (69 boys) aged 11-12 years from two primary schools in the Lower Hunter region of NSW. One school served as the control group (n=57) with those from the intervention school assigned to either a nutrition education only (NE, n=35) or nutrition education plus garden group (NG, n=35). Dietary intake data was collected from all participants using repeated 24-hour recalls.

Outcomes

For the intervention groups combined there was an increase in vegetable intake in both boys and girls, with a greater in girls, $p > 0.05$. There was a significant mean (SD) increase in vegetable intake in boys in the NE group [0.90 (1.57) serves/day, $p=0.048$] compared to NG boys, -0.76 (2.70). From baseline NG girls had an increase in vegetable intake of 0.43 serves/day whilst NG boys decreased their intake by 0.76 (2.70) serves/day.

Conclusion

Preliminary findings indicate that a nutrition intervention which includes a nutrition curriculum may help to increase vegetable intakes in primary school children. However due to the small sample size and confounding factors, such as teacher expertise and experience, it is unclear if a school garden approach provides additional benefits. Further studies are needed to investigate how a school garden can be utilised to optimise vegetable intakes, particularly in boys.

Home food availability mediates association between maternal nutrition knowledge and children's food intakes

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Background

Evidence suggests that mother's nutrition knowledge (NK) impacts directly on the quality of a child's diet however, defining what we mean by NK is challenging and may include assessments of knowledge of dietary guidelines; of nutrients in food, and/or; of 'best' food/meal choices. Home food availability is also directly associated with child diet and may reflect aspects of the food provider's NK. Understanding which aspect of NK impacts home availability informs the design of focussed interventions to support parents to promote healthy eating.

Objective

These analyses tested the hypothesis that home food availability may mediate associations between maternal nutrition knowledge and child diet.

Design

Women aged 18-46 years (n=536), living in socioeconomically disadvantaged neighbourhoods with dependent children (aged 5-12 years), provided data on their child's diet, home food availability, nutrition knowledge (specifically knowledge re best food/meal choices) and a range of sociodemographic characteristics.

Outcomes

We assessed correlations (adjusting for child age) between NK and child food intake; NK and home food availability; and home food availability and child food intake. In all instances significant associations were found, thus meeting initial conditions for mediation proposed by Baron and Kenny. Overall, the indirect effect of home food availability on the association between NK and fruit intake (beta = 0.05, $p < 0.001$), vegetable (beta = 0.03, $p < 0.05$), salty foods (e.g. crisps) (beta = -0.04, $p < 0.05$), and soft drink intake (beta = 0.05, $p < 0.001$) were all significant.

Conclusion

Home food availability is a mediator of the associations between maternal NK and the quality of a child's diet. This supports a focus on nutrition education that expands the home food provider's understanding of what foods to buy, prepare and serve. Further exploration of these associations will provide a stronger evidence base upon which to inform 'best bets' for nutrition promotion seeking to support children's healthy eating.

The role of packaging on sandwich quality and safety in school lunch boxes

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Background

Recently, there has been increasing discussion on the safety and quality of food in school lunch boxes. Type of food, storage temperature and packaging are all likely to determine the quality of the final consumed product. The end result may not just be food spoilage but also an increased risk of food-borne disease. Although certain foods have been identified as "at risk" when provided in school lunch boxes, limited study has been undertaken to determine whether risks can be reduced.

Objective

The objective of this study is to examine methods to improve quality and safety of lunch box food by studying the interaction between storage temperature and packaging material. This study uses common sandwich fillings found in school lunches, with the aim of establishing simple criteria to improve the likely safety and quality of sandwiches when stored under conditions representative of a normal school lunch.

Design

Three different types of wrappings; cling wrap, zipper bag and brown bag, were tested on two different types of sandwiches; ham salad (lettuce, cheese and ham) and vegemite. Both sandwiches had butter as a standard spread. The sandwiches in the three different wrappings were incubated over a period of three hours at 5, 25 and 45 °C. After incubation, the sandwiches were homogenized with peptone water and then enumerated onto MC, TPA and ROSE agar for the detection of *E.coli*, total aerobic and moulds and yeasts counts respectively. Changes in sandwich weight and appearance were also recorded.

Outcomes

It was found that there were significant differences between the type of wrappings used, with brown bag packed sandwiches showing significantly less quality after storage. Regardless of wrappings and types of sandwiches, the microbial counts were significantly higher at 25°C. At 5°C microbial counts remained relatively stable. Visibly sandwich appearance was negatively affected at increasing temperature.

Conclusion

Quality of sandwiches is affected by different type of wrappings as well as storage temperatures.

Concurrent Session 18: Medicinal Foods

Please cite this paper as: Conference Abstracts Nutrition Society of Australia and Nutrition Society of New Zealand 2009: IV. AMJ 2010, 1, 1, 28-45. Doi 10.4066/AMJ.2010.208

In vitro fermentation of co cultures to rice dietary fibre and its implications in probiotic technologies

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Background

This study was done to explore the fermentation of rice fibre with co-cultures of probiotics.

Objective

This study was the first investigation of the effect of the interaction of paired and more than paired cultures of probiotics on growth and metabolite formation of probiotics on rice dietary fibre

Design

The fermentation of rice dietary fibre was measured by the cell yield, pH, optical density specific growth rate, biomass and SCFA (GLC) using nine co-cultures of four probiotics (*Bifidobacterium breve, Bifidobacterium longum, Lactobacillus rhamnosis Lactobacillus acidophullu),* at 0, 6, 24 and 48 h incubation. The results from the fermentation of the soluble, insoluble and total dietary fibre (SDF, IDF and TDF) of two rice varieties were compared.

Outcome

There were no significant differences ($p< 0.05$) in most of the growth kinetic parameters in the fermentation of the six different rice fibre fractions, however co-cultures had a preference for glucose as a fermentation substrate rather than the fibre fractions. *Bifidobacteria* produced a higher cell count than *Lactbacillus* species after 24 and 48 h of fermentation ($p<0.05$). There was evidence of synergistic activity with increased growth observed when *Lactobacilli* and *Bifidobacteria* were grown together. Growth was limited by the pH reaching 4.2-4.45. Specific growth rates of the co-cultures varied for different culture combinations. Combinations of same species produced less biomass than the other combinations. SCFA formation was followed as Acetate<propionate< butyrate. Combinations of same species had significantly ($p<0.05$) less SCFA than mixed combinations. Total dietary fiber had contributed to form most SCFA from combinations.

Conclusion

Bifidobacterium breve + Bifidobacterium longum + Lactobacillus rhamnosis was the combination producing most growth and SCFA with TDF, SDF, IDF of two rice varieties and glucose as substrate for growth and TDF for SCFAs. Synergism between microorganisms in co-cultures affected the degree of fermentation of dietary fibre and it is possible to select a best combination for rice fibre + probiotic products.

Acute effects of resveratrol (resVida®) supplementation on cardiovascular risk factors

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Background

Flow mediated dilatation in the brachial artery (FMD) is a biomarker of cardiovascular health and circulatory function. Impaired FMD is associated with several modifiable cardiovascular risk factors such as obesity and hypertension. Various food ingredients including polyphenols have been shown to improve FMD. It has been suggested that resveratrol, a polyphenol found in grapes and red wine, may offer similar benefits[1].

Objective

We investigated whether acute consumption of resveratrol (resVida®) could enhance FMD and attenuate BP rises in response to sub-maximal exercise and whether there was a dose-response relationship for these improvements.

Design

19 overweight/obese (BMI 25-35 $kg.m^{-2}$) untreated hypertensive (systolic BP 130-160 mmHg or diastolic BP 85-100 mmHg) men or post-menopausal women were randomly assigned to consume three single doses of resveratrol (0, 30, 90 and 270 mg) at weekly intervals in a double-blind, randomised cross-over comparison. One hour after consumption of resveratrol, FMD was measured and BP responses to exercise were tested by continuous beat-to-beat monitoring (Finapres™) for 5 min whilst seated at rest on a cycle ergometer, followed by 10 min of cycling at 75% of age-predicted maximum heart rate. Data were analysed using a generalised estimating equation and linear regression versus $\log_{10}$ dose of resveratrol.

Outcomes

14 men and 5 women (aged 55 ± 2 years, BMI 28.7 ± 0.5 $kg.m^{-2}$ and BP 141 ± 2 / 89 ± 1 mmHg) completed this study. There was a significant ($P=0.006$) dose related increase in FMD (4.1 ± 0.8% at 0mg to 7.7 ± 1.5% at 270mg). However, there was no treatment effect on the BP response to exercise.

Conclusion

Acute consumption of resveratrol (resVida®) resulted in dose-related improvements in FMD. This preliminary finding suggests that resveratrol is an active mediator of the

purported cardiovascular health benefits of red wine and grape consumption.

Reference

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Dietary iodine deficiency among pregnant women in the Gippsland region

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Background

Overall Australia is iodine deficient. However, in the National Iodine Nutrition Study (NINS), Victoria had the worst status with regard to iodine deficiency in school children. Our study focuses on regional and sub regional iodine status, which extends the work of the NINS team and will provide data on the situation in Gippsland. Preliminary results from historical research, water testing and retrospective neonatal thyroid data analysis indicate dietary iodine deficiency may be a reemerging problem in the Gippsland region. Even mild iodine deficiency in pregnancy is a risk factor for babies as it may result in their impaired intellectual development; this is the most serious consequence of dietary iodine deficiency.

Objective

To look at the iodine status of pregnant women and to understand factors affecting their iodine intake status.

Design

This is a cross-sectional study, and participants have been recruited from all Gippsland shires.

Outcomes

All participants are eating less bread than is needed to provide them with adequate iodine under the proposed iodine fortified bread programme. In addition, other major sources of iodine (seafood, seaweed, iodised salt and supplements) are not being consumed/ taken by these participants.

Conclusion

National iodine supplementation programme is planned to commence in 2009 by fortifying bread with iodine. Results from our study indicate this programme is unlikely to supply sufficient amount of iodine to the most vulnerable groups: pregnant women and lactating mothers and their babies.

Improving thiamine status in people with type 2 diabetes: the role of Australian pork

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Background

Thiamine levels in Australian pork are approximately 0.8mg/100g raw and 1.2mg/100g cooked weight and are much higher than other protein sources. Type 2 diabetes is a major public health problem driven mainly by increasing obesity. Moderate weight loss is an effective management tool for type 2 diabetes with some evidence that a higher protein diet has benefits over the traditional high carbohydrate diet. Emerging evidence suggests an increased prevalence of low thiamine concentrations in type 2 diabetes that may be linked to markers of vascular disease, correction of which may potentially decrease the risk of microvascular complications.

Objective

To determine the effect of a high protein (HP), high thiamine diet containing 180g pork (raw weight) 4 times per week compared with a traditional high carbohydrate (HC), adequate thiamine diet during weight loss on thiamine status in people with type 2 diabetes.

Design

Randomised, parallel 16 week, weight loss study in 83 overweight/obese men and women with type 2 diabetes, matched for age, gender, weight and diabetes medication and control. The HC diet was designed to contain 55% carbohydrate, 20% protein, 25% fat and 1.2 mg thiamine/day and the HP diet 40% carbohydrate, 35% protein, 25% fat and 2.8 mg thiamine/day

Outcomes

Fifty-nine subjects completed the study. (Age (yr) 56.0 ± 8.0 HC, 56.4 ± 6.9 HP, BMI (kg/m^2) 34.9±4.7 HC, 36.1±4.4 HP). Weight decreased in both groups (101.0 ± 13.0 to 91.5 ± 13.3 kg, 105.2 ± 13.0 to 93.8 ± 13.7 kg, HC vs HP, $P<0.01$ for time, no diet effect). Thiamine intake from food records was 1.2 ± 0.2 mg vs 2.8 ± 0.5 mg, HC vs HP ($P<0.05$). Whole blood thiamine pyrophosphate was 221.0 ± 50.7 nmol/L before and 195.2 ± 36.3 nmol/L after weight loss, HC and 216.4 ± 52.3 before and 221.0 ± 40.4 nmol/L, HP (NS for time, $P<0.05$ for diet interaction). Levels in HP increased by 4±50 nmol/L and decreased by 25±53 nmol/L in HC.

Conclusion

A HP diet, containing pork, maintained thiamine status during weight loss in people with type 2 diabetes compared with a traditional HC diet. This work was supported by the Pork Cooperative Research Centre.

Phytosterols combined with oils rich in eicosapentaenoic acid and docosahexaenoic acid: a potential treatment for hyperlipidemia

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Background

The combined supplementation of omega-3 fatty acids and phytosterols have been shown to reduce circulating lipid levels in both a complementary and synergistic manner. To further optimise this dietary combination, it is important to determine the extent of any differential effects between EPA and DHA.

Objective

To compare the effect of oils rich in EPA and DHA combined with phytosterols on plasma lipid profile.

Design

A three-week randomised, placebo-controlled study with six intervention groups. Individuals with combined hyperlipidemia were randomly assigned to receive either EPA-rich capsules (EPA:DHA = 4.6) or DHA-rich capsules (EPA:DHA = 0.2) or placebo (sunola oil) capsules, either alone or in combination with 2g/day of phytosterols provided as an enriched spread.

Outcomes

One-hundred and eighteen individuals completed this study (47 male and 71 female). Participants had a mean (± SEM) age of 56±1.6 years, BMI of 26.3±0.8 kg/m^2 and baseline total cholesterol and triglyceride concentration of 6.5±0.07 and 1.6±0.07 mmol/L, respectively. Supplementation with EPA or DHA alone, significantly reduced triglycerides and increased HDL-cholesterol, whilst phytosterol supplementation significantly reduced total-cholesterol ($P<0.001$), LDL-cholesterol ($P<0.001$) and triglycerides ($P=0.03$). Further reductions in plasma total-cholesterol, LDL-cholesterol, triglycerides and increases in HDL-cholesterol were found when phytosterols were combined with EPA ($P<0.01$ for all) or DHA ($P<0.01$ for all). Further exploration of the data showed a phytosterol x DHA interaction for total-cholesterol ($P<0.01$) and LDL-cholesterol ($P=0.03$).

Conclusion

Our findings suggest that consuming a phytosterol-enriched spread in combination with DHA supplementation, provides greater improvement in overall plasma lipid profile, compared to the combination of phytosterols with EPA or either functional food consumed alone. Thus phytosterols combined with oils rich in DHA offers individuals with mixed hyperlipidemia a more comprehensive lipid lowering treatment.

Analysis of vitamin D in meat: an old approach to a new problem

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Background

The analysis of vitamin D in food chemistry is a complex procedure. Many articles in the literature are present and generally involve extensive clean up procedures aimed at eliminating interfering compounds, followed by HPLC analysis. Despite this, the analytical phase is still inefficient. Large quantities of cholesterol bypass the cleanup phases, and overload the analytical HPLC column. Cholesterol does not absorb UV and does not appear as a peak. However in large quantities, chromatogram smearing and poor analysis repeatability is evident. This aspect has never previously been properly addressed. Instead, to overcome this problem, authors have chosen to wash out analytical HPLC columns in between each sample to be analysed. Silver ion chromatography has been used for decades to separate structurally similar lipids, according to the number double bonds. This may be applied to separate cholesterol with one double bond from vitamin D with three.

Objectives

To establish and optimise, a reliable, robust, and accurate extraction and analytical methods for vitamins D_2, D_3 and their 25 hydroxy metabolites by column chromatography on silica impregnated with silver ions.

Design

Samples of meat were saponified with ethanolic potassium hydroxide and nonsaponifiable lipids were extracted with an ether mix. This was then acetylated with acetic anhydride and pyridine before being applied to an in-house prepared silver/silica column. This was then followed by semi-preparative HPLC, and analytical HPLC.

Outcomes

Following silver nitrate chromatography, the lipid extract visibly appears less opaque compared to traditionally prepared samples. This may result in the increased lifespan of the semi-preparative HPLC column. Analytical chromatograms obtained from this procedure have similar amounts of UV absorbing peaks compared to those obtained by traditional methods. However, with the elimination of cholesterol, smearing and repeatability is greatly improved. This allows more consistent elution times and continuous analysis without the need for intermediate column washing.

Conclusion

Preliminary silver ion chromatography has greatly improved the reliability, repeatability and efficiency of HPLC determination of vitamin D and 25(OH)D in meat.

Plenary Session 6: Function Foods and Nutraceuticals

Please cite this paper as: Conference Abstracts Nutrition Society of Australia and Nutrition Society of New Zealand 2009: IV. AMJ 2010, 1, 1, 28-45. Doi 10.4066/AMJ.2010.208

Plant sterols

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Introduction

Plant sterols are the plant equivalent of cholesterol with an additional methyl or ethyl group in the side chain (for sitosterol and .campesterol respectively). Plant sterols were used in the 1960s in high doses (10-30g/day) for cholesterol-lowering and made a reappearance as sitostanol ester (a hydrogenated form of sitosterol) in margarine marketed by Raisio in Finland in the early nineties. Many different formulations as both free and esterified forms have appeared over the last 10 years. On average 2-3g/d of sterol or stanols lowers LDL cholesterol by about 10%

Mechanisms

In humans, about 40 to 60 per cent of cholesterol is absorbed (whether it comes from the diet or the liver makes no difference). Plant sterols (both free and with an ester attached) compete physically with cholesterol at the surface of the absorption package in the intestine and displace it, rendering it unable to be absorbed. However, no matter how much plant sterol there is in the intestine, not all the cholesterol can be displaced. Plant sterols can inhibit cholesterol absorption by 25 to 56 per cent, with doses as low as 300mg of plant sterols being effective (23 to 35 per cent inhibition), but there is a clear plateau at about 60 per cent inhibition, regardless of the dose of plant sterol eaten (Shin et al 2005, Normen et al 2000, Richelle et al 2004).

There is also a limit to the degree by which LDL cholesterol can be lowered. This is because of the limitation in cholesterol absorption inhibition, as well as the counter regulatory increases in cholesterol synthesis (ie as cholesterol absorption goes down, cholesterol synthesis increases in order to keep the level of cholesterol in the liver relatively constant). Gylling and Miettinen (1995) estimated, based on sterol balance studies with neomycin and sitostanol that LDL cholesterol would still be 2.5 mmol/L even with 100 per cent cholesterol absorption inhibition.

A recent meta analysis of 141 sterol studies has shown a maximum effect of about 12 per cent lowering of LDL cholesterol at 4g/day (Demonty et al 2009). The same meta analysis showed that the level of fat in the carrier had no effect on the LDL cholesterol-lowering, nor was there a difference between dairy foods, spreads and solid foods.
There is also some modest evidence that plant sterols may influence prostate cancer development.

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Designing healthy, tasty, tender lamb focused on the consumer

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Background

The prime lamb industry in Australia has undergone very significant change since the early 1990's when the price of lamb was relatively low and the final consumer product considered fatty, old fashioned and losing market share when compared to other meats. Since this time the prime lamb has become leaner and levels of consumption have been maintained despite over a 2 fold increase in retail price. Increased production and higher prices have resulted in 3 fold increase in gross national value.

Objective

To review the factors that contributed to the recent success of the lamb industry and then to describe the latest research, where a balanced portfolio of consumer traits is being measured and managed to improve lamb even further.

Outcomes

In the 1990's industry identified programs to improve the consumer acceptability of lamb so as to increase on farm profitability for Australian lamb producers. Firstly a world leading genetic improvement program, Lambplan™, was initiated and then commercialised to facilitate rapid genetic

gain for larger, more muscled and leaner lambs. At the same time the larger carcase weight allowed fabrication into a wide range of more consumer acceptable lean lamb cuts termed 'trim lamb' that offered more flexible cut x cook outcomes. Combined with these major initiatives was research and adoption for more efficient production systems on farm and the development of more sophisticated producer/processor relationships. More recently new research was undertaken to define and deliver commercial systems for underpinning the eating quality of lamb. Finally the industry also invested in marketing to promote the product overseas and domestically. Consequently the Australian lamb industry has matured into a vibrant and profitable enterprise for all sectors of the supplychain. In the last 2 years the industry has focused on 'where to next' with respect to research to underpin future product improvement. After extensive consultation it was concluded that further improvements of lean meat yield was still a high priority but this should be matched with simultaneous research to underpin high standards of eating quality (tender, juicy and flavoursome) and human health attributes of lamb cuts (1).

Lamb and lean meat yield are very closely associated for efficiency reasons both on and off farm given that laying down fat in the live animal and subsequent removal post slaughter is a costly inefficiency. However lean meat yield is also critical for a successful consumer product especially given the small carcase size (compared to beef/pork) resulting in most often multiple muscles are sold as one cut. For example a lamb rump can be composed of up to 5 muscles with seams of adipose tissue (intermuscular fat) between muscles that are not practical to remove by further fabrication and this makes leanness or reduced subcutaneous and intermuscular adipose tissue a high priority. In addition many lambs cuts are sold with the bone included, making the muscle to bone ratio an important part of consumer preference. Given the fundamental importance of lean meat yield and the drive for more muscle and less fat there is a risk that this may negatively impact on eating quality and human health attributes if extremes of lean meat yield are pursued in isolation (1). To better manage the 3 areas of consumer appeal (lean meat yield, eating quality, human health attributes) a project has been initiated via the Cooperative Research Centre for Sheep Industry Innovation (Sheep CRC) in close collaboration with Meat & Livestock Australia. The project is underpinned by a large genetic technologies experiment based on the production, and subsequent detailed measurement of 10,000 slaughter lambs (2,000 every year for 5 years), derived from 500 Industry sires (100 every year), produced from 8 different production sites around Southern Australia (2). This resource will allow a thorough understanding of the genetic and production parameters required to underpin the 3 areas of consumer appeal. Key traits for eating quality include tenderness and intramuscular fat with the aim being to maintain lamb as a delicious tasting, tender and juicy product. For intramuscular fat the aim is to maintain the level at 4-5% (the current industry average). The human health traits of interest are those that give red meat a competitive advantage over other 'white' meat and these include Fe, Zn and omega 3 fatty acid level. For iron and zinc, the aim is to maintain the product as a 'good source' and for omega 3 underpin lamb as a 'source' (1).

Conclusion

The early data coming from the Sheep CRC project very clearly indicates a significant genetic component underpinning the consumer traits that can be further managed by relatively simple production parameters. The knowledge gained, combined with the industry's ability to utilize the innovation, will maintain lamb's current and hard earned position as an elite product.

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Functional effects of omega-3 fatty acids: EPA vs DHA

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Background

There is much evidence that diets rich in n-3 fatty acids derived from fish and fish oils, specifically eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), protect against cardiovascular disease. Prospective population studies and secondary prevention trials have demonstrated that n-3 fatty acids reduce coronary mortality and/or sudden death, particularly in patients with pre-existing coronary disease. Omega 3 Fatty acids have a wide-range of biological effects, including benefits on blood pressure and vascular reactivity; cardiac function; lipoprotein metabolism; platelet function, cytokine production; inflammation; thrombosis and oxidative stress. Controlled studies in humans now demonstrate that DHA, although often present in lower quantities, has equally important anti-arrhythmic, anti-thrombotic and anti-atherogenic effects.

Objective

This paper will review the independent effects of EPA and DHA on cardiovascular risk factors in humans. In particular our own controlled clinical trials have compared the independent effects of EPA and DHA in individuals at increased risk of cardiovascular disease, namely overweight hyperlipidaemic men and treated-hypertensive, Type 2 diabetic men and women. It will address and compare the biological effects of EPA and DHA and the potential mechanisms through which they may affect cardiovascular disease risk factors.

Design

Data will be presented from studies evaluating the independent effects of EPA and DHA in individuals with

dyslipidaemia or Type 2 diabetes mellitus. The purified encapsulated fatty acids were provided by a program jointly supported by the National Institutes of Health (USA) and the Fish Oil Test Materials Program. Our aim was to evaluate effects on blood pressure and vascular reactivity; serum lipids; platelet and cardiac function; cytokine production; inflammation; thrombosis and oxidative stress. In two placebo-controlled interventions, we examined the effects of 4g/day of purified EPA or DHA compared with olive oil in (i) overweight hyperlipidaemic men, and (ii) in treated-hypertensive Type 2 diabetic men and women, while continuing their usual diets for 6 weeks.

Outcomes

In individuals with mild hyperlipidaemia we showed that the blood pressure lowering effects of n-3 fatty acids are most likely due to DHA, rather than EPA. 24-Hour heart rate in the same individuals was reduced following DHA, but not after EPA. Vascular function was assessed by measurement of blood flow in the forearm using venous occlusion, strain gauge plethysmography during sequential intra-arterial administration of vasoactive agents. We showed that DHA but not EPA, significantly improved forearm blood flow in response to both vasodilator and vasoconstrictor agents. The effect appeared to predominantly involve improvements in endothelium-independent mechanisms, which likely contributed to the selective blood pressure-lowering effect observed with DHA compared with EPA.

We showed that EPA and DHA are equally effective in reducing serum triglycerides, but neither affected serum total cholesterol. Increases in HDL-cholesterol and HDL_2-cholesterol were evident following DHA, but not EPA. Moreover, small increases in LDL-cholesterol following DHA supplementation were related to an increase in the LDL-particle size, which might be considered anti-atherogenic.

n-3 Fatty acids suppress cell-derived cytokines and our data has shown that both EPA and DHA were responsible for reducing circulating TNF-α. We have shown that n-3 fatty acids reduce *in vivo* oxidative stress: F_2-isoprostanes were reduced after EPA or DHA supplementation. In individuals with Type 2 diabetes mellitus, we showed that positive associations between changes in F_2-isoprostanes and changes in glycaemia and measures of inflammation, suggesting that to some extent, diabetic control and inflammation may be interrelated with oxidative stress in these subjects.

Conclusion

The available evidence strongly suggests that EPA and DHA have differing haemodynamic and anti-atherogenic properties. The effects of EPA and DHA may also differ depending on the target population.

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