Primary School Nutrition in Lancashire:

An Evaluation of Current Practice with Reference to Nutritional Guidelines

By

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ABSTRACT

Background: Many studies have highlighted the benefits of good nutrition for improved cognitive performance and educational outcomes (Hoyland *et al,* 2008). The recognition that children's diets were nutritionally inadequate, led to the re-introduction of statutory nutritional standards in 2001 (Nelson *et al,* 2004). However, lack of enforcement, led to revised Government Nutrient Based Standards (GNBS), with the recommendation that primary schools comply with regulations by 2008. The purpose of this research was to evaluate whether school meal provision in Lancashire primary schools, is meeting GNBS, 2007, and secondly, whether a mid-morning snack has an impact on the cognitive performance of primary school children.

Methods: One Lancashire primary school was selected as a representation of 525 primary schools across Lancashire that receives nutrition provision from Lancashire County Council Commercial Group (LCCG). School meals were collected on a daily bases over 3 weeks, and prepared for laboratory analysis. The nutritional composition of the school meals were analysed using both direct chemical analysis and indirect food composition database analysis. One-sample t-tests were conducted to compare the mean differences derived from both analyses per meal, with GNBS. For the second phase, 21 children (aged 6-7) from the same school participated in a short memory test on two occasions, test 1 before a mid-morning snack, and test 2 after a mid-morning snack, to assess cognitive performance.

Results: Chemical and database analyses revealed the energy content of the LCCG school meals were significantly below the minimum GNBS of 530 kcal, ± 5% per meal (chemical: 392 ± 72 kcal/meal, database: 411 ± 44 kcal/meal). Mean total fat values (chemical: 8.28 ± 2.1g/meal, database: 15.78 ± 3.5 g/meal) were significantly below the maximum GNBS of 20.6g/meal. Carbohydrate content (chemical: 52.66 ± 12.22 g/meal, database: 53.67 ± 7.49g/meal) was significantly below the minimum GNBS of

70.60 g/meal, however protein content exceeded the minimum GNBS of 7.5g/meal (chemical: 13.21 ± 2.9 g/meal, database:16.30 ± 3g/meal). Sodium content also exceeded the maximum GNBS of 499mg/meal (chemical: 500 ± 179 mg/meal, database: 516 ± 160mg/meal). Calcium content (chemical: 210 ± 81 mg/meal) met the GNBS, whereas (database: 171 ± 46 mg/meal) did not meet the GNBS, however both values derived were not significantly different from the GNBS 193mg/meal.
Cognitive tests revealed a significant improvement in memory function, after consuming a mid-morning snack (mean score 8.67 ± 1.42) than without a snack (mean score 5.81 ± 2.58) ($p < 0.001$).

Conclusion: The analysis of primary school meals as provided revealed that generally the GNBS were met for protein and total fat, but not for carbohydrate. Total energy was significantly lower than minimum GNBS, however this has been observed by other studies and has been suggested that lower energy content may not be unwelcome. Of greater concern is the high sodium content of the meals. Findings revealed by the cognitive testing, suggest that providing a snack mid-morning can enhance cognitive performance.

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ABBREVIATIONS

BMI	Body Mass Index
BuSH	Ethics Committee Built, Sport and Health (UCLAN)
CCT	Compulsive Competitive Tendering
CHO	Carbohydrate
CWT	Caroline Walker Trust
COMA	Committee on Medical Aspects of Health
DALY’s	Disability Adjusted Life Years
DfES	Department for Education and Skills
DfEE	Department for Education and Employment
DfE	Department for Education
DH	Department of Health
DRV’s	Daily Recommended Values
FBS	Food Based Standards
FSA	Food Standards Agency
FSM	Free School Meal
ICP-MS	Inductively coupled plasma mass spectrometry
IDA	Iron Deficiency Anaemia
LCCG	Lancashire County Council Group
LEA’s	Local Education Authorities
NCMP	National Child Measuring Programme
NCD’s	Non-Communicable Diseases
NDNS	National Diet and Nutritional Survey
NHS	National Health Service
NSFS	National School Fruit Scheme
SACN	Scientific Advisory Committee on Nutrition
SFT	School Food Trust

SFVS	School Fruit and Vegetable Scheme
SMRP	School Meals Review Panel
WND	Windiets Nutrient Database
WHO	World Health Organisation
UK	United Kingdom

CHAPTER 1

INTRODUCTION

1.1 The importance of nutrition in childhood

A good diet during childhood is the fundamental structure of a healthy adulthood, because healthy children, who achieve optimal nutritional status, are more likely to progress through life as healthy adults. Nutrition plays a major role in human growth and development, health maintenance, prevention of disease and many other important functions of the body and brain, throughout an individual's lifespan (Wahlqvist *et al*, 2003). The World Health Organisation, express the importance of nutrition as, '*Nutrition is a fundamental pillar of human life, health and development across the entire life span. From the earliest stages of fetal development, at birth, through infancy, childhood, adolescence and on into adulthood and old age, proper food and good nutrition are essential for survival, physical growth, mental development, performance and productivity, health and wellbeing'*(WHO *pg 11,* 2000).

1.2 Well-balanced nutrition for children

Childhood nutrition should be a balance between high energy, nutrient dense foods required for growth and development and physical activity to promote good health (Tidy, 2007). The ideal diet for children is one that varies in content, texture and taste, growing children need a wide variety of foods which will supply a nutritionally adequate combination of macro and micronutrients (Geissler & Powers, 2009). This will make certain they receive all the energy, essential nutrients and nourishment to grow into healthy adulthood. Compared to their size, children's energy and nutritional needs are high, however because the amount of food that can be taken in at any one time is limited (Geissler & Powers, 2009), foods need to be both energy and nutrient dense (Dare & O'Donovan, 2002). Frequency of food consumption is also very important for children, to avoid a deficit in nutrient availability throughout the day (Duggan *et al*, 2008). A child's daily diet needs to be comprised of three small meals, plus two or three healthy snacks between meals (Dare & O'Donovan, 2002). In addition, meals should always be planned rather than opportunistic (Geissler & Powers, 2009).

1.3 Children and poor diet

Over the last decade's, concern regarding children's diets has become a major source of preoccupation in developed countries, as there seems to have been a continuous shift in children's dietary choices which could affect their long term health (Ames, 2006). It has become evident that there has been a much higher consumption of energy dense foods, which are micro-nutrient poor and excessive in fat, sodium and sugar (Popkin & Gordon-Larsen, 2004). The WHO 2003, concluded that a poor diet is one of the key risk factors for non-communicable diseases (NCD's), including type 2 diabetes, cardiovascular disease, osteoporosis and several cancers (Scarborough *et al*, 2011). In 2008, 57 million (63%) of deaths globally, were said to be attributed to NCD's (WHO 2011). According to the WHO 2002, poor diet is related to five of the ten causes of disease burden measured in DALYs (Disability Adjusted Life Years) in developed countries.

Findings by the Medical Research Council showed that children's diets were healthier in 1950 than 1990 (Prynne & Paul *et al,* 1999). Though food rationing was in place, findings suggested that the nutrient intakes of children in 1950 were better because the amounts of bread, milk and vegetables consumed were closer to the nutritional guidelines of 1990, plus school milk at this time was free to all children. Children in the 1950's consumed less sugar, plus their calcium intakes were higher which would have benefited their bone health, and their vegetable intake would have protected them against heart and respiratory disease and certain forms of cancer (Gillard, 2003).

The National Diet and Nutrition Survey (NDNS) is the main source of information on children diets in the UK. The NDNS 2000, revealed an array of issues regarding children's diets (Gregory *et al,* 2000). At this time research reported that more than 90% of children were eating more saturated fatty acids than recommended and over 55% were consuming more than the maximum recommended amount of salt. What's more, 96% of children below the age of 6 did not eat the recommended five or more portions of fruit and vegetables a day (NHS, 2000) and 20% of children ate no fruit at all (The Food Commission, 2001). In 2008, the Scientific Advisory Committee on Nutrition (SACN), evaluated the NDNS, 2008, and reported that though children's diets had improved certain areas still needed attention. For example, mean total fat intake met the DRV's (No more than 35% of food energy), but intakes of saturated fatty acids exceeded the DRV's. Furthermore, children's intakes of vitamins and minerals tended to fall below the DRV's (SACN, 2008), leading to a sub-optimal nutritional status (Shepherd, 2008).

1.4 The relationship between poor dietary factors and health in children

A poor diet can leave children susceptible to illness, although the NDNS, 2008-2011 suggest that children's diets have improved, the health problems associated with a poor diet, such as obesity, type 2 diabetes and high blood pressure continue to escalate. The

SACN energy report 2011, suggests this may due to under-reporting, as the NDNS relies on self-reported diet diaries, (Rennie *et al*, 2005). One of the most researched health problems related to a poor diet is obesity and overweight, Freedman *et al,* 2001, described obesity as one of the most frequently occurring, nutritional disorders amongst children. In 2000, the WHO described the level of obesity as a global epidemic, however in the last three decades the prevalence of obesity has doubled (WHO, 2013), and now more than 40 million children worldwide, under the age of five are defined as over weight (WHO, 2013). Evidence of this is revealed by the UK National Child Measuring Programme (NCMP) 2012, which has shown a continual rise in the prevalence of overweight and obesity in primary aged children in the UK. NCMP, data recorded in 2011-2012, reports that over a fifth (22.6%) of reception aged children and a third of year six children (33.9%) were either overweight or obese. Furthermore, Scarborough *et al*, 2011, suggested that children who are overweight or obese are more likely to be so into adulthood.

Research has suggested that poor diets which are high in energy dense foods are generally low in micro-nutrients. This can lead to a double burden of children being both overweight and undernourished at the same time (Gillis & Gillis, 2005). There are growing concerns regarding the low micro-nutrient intake of many children in the UK, the NDNS 2008-2011, reported vitamin D intakes to be below the DRV's in many children, even after including the contributory dietary supplements. For many children this could lead to a greater risk of low bone mass, osteoporosis and the likelihood that they will not reach their optimum height in adulthood (Bueno & Czepielewski, 2008). Rickets, a childhood disease which is primarily caused by a lack of vitamin D in the diet was thought to be almost eradicated, however recently there has been an increased prevalence of this disease. It has been suggested that the low levels of vitamin D in children's diets along with a lack of outdoor time has resulted in this increase, consequently this led to a NH recommendation in 2011 that all children up to five years should be given vitamin D supplements (Lowden, 2011). A study by Jennings *et al,* 2010, on the micronutrient intakes of children aged 7-10 years in the UK, reported that intakes of vitamin D, vitamin B (12), iron and calcium were even lower than the findings in the NDNS, 2008-2011. Results showed that of the eighty-five children involved in the study, 73% failed to reach the DRV's set by the Department of Health (FSA, 2006), for zinc, and 68% failed to meet the DRV's for potassium.

Though the NDNS 2008-2011 have suggested that children's diets were showing some improvement, the Office of National Statistics suggests that this may now be reversing (Department for Environment Food & Rural Affairs (DEFRA), 2013). An economic downturn which has shown stagnating family income and rising food prices (DEFRA, 2013), has led to many families with young children reducing their intake of fruit and vegetables and switching to less healthy processed foods, which has contributed to increases in saturated fatty acids and sugars in their diet (Institute for Fiscal Studies, 2013). Following the increasing financial pressure on families, Government plan to support families, by offering a free school lunch to all infants in year 1 &2 from 2014, and secondly, to increase expenditure on school kitchens and dining facilities (GOV.UK, 2013).

1.5 School Setting

It has been suggested by the Health Education Trust 2006, that childhood is a critical time for lifelong eating habits and preferences to be developed. It has long been recognised that the school setting can provide a valuable opportunity to influence child health through policy measures, education and food provision (CDC, 1996). Sahota *et* *al* 2001, suggested that young children are particularly responsive to healthy eating messages, and as they spend more time in school than in any other activity, this provides the school with a unique opportunity to practice health promoting behaviours which can also be reinforced through the school curriculum (Rana & Alvaro, 2010). The WHO, 1998, suggests that health, education and nutrition, support and enhance each other, as good nutrition supports education and vice versa.

A study funding by the DfES investigating the wider benefits of learning states that a healthy school meal can improve children's concentration, and help them to reach their potential in life (Sorhaindo & Feinstein, 2006). School meals in the UK make a very important contribution to children's daily energy and nutrient intake, as primary school children consume approximately one-third of their daily food intake at lunch time, which is provided either by school or as a packed lunch brought from home (Gregory *et al*, 2000). Gregory *et al*, 2000 also reported that primary school girls had poor intakes of zinc and high intakes of sodium, even so he suggested that school meals went some way to improving this.

A lifestyle survey in 2002, reported that the school meal was especially important for some children and particularly those of low socioeconomic status, as school food may be their only opportunity to receive a balanced nutritious meal (Sodexho, 2002). A Government paper 'Choosing Health' (2004) suggested that inequalities in society still exist as they point out; children from poorer households eat about half of the amount of fruit and vegetables that wealthier households do. Armstrong *et al*, 2003, reported that children in poorer households were at a 30% higher risk of obesity, and a 50% higher risk of under-nutrition compared to children from wealthier households. A study by

Walker *et al* 1995, carried out research on how low-income families eat, findings showed that mothers served foods that they knew their children liked to avoid wastage, and these consisted primarily of low-cost, high density, micro-nutrient poor foods. The Sodexho lifestyle study, 2002 reported that at least 8-9% of children from poor households don't consume breakfast before school. It has been suggested that the impact of food poverty on children may be reduced to a certain extent, by the availability of a nutritious free school meal, and that school nutrition may provide a route to which disparities between socio-economic background and educational outcomes can be targeted. A Free School Meals (FSM) pilot study undertaken in 2009-2011, by the Department for Education (DfE) and Department of Health (DH) reported surprising benefits academically. Children in the pilot areas were doing better in exams and making much faster progress than children outside the pilot areas (DfE, 2010).

However, there has been extensive controversy regarding school nutrition provision in the UK. In 2005, a Celebrity Chef Jamie Oliver hosted a television documentary 'School Dinners', which created much debate regarding the nutritional standards in UK schools. Schools in the UK were shown to be serving highly processed foods with very little nutritional value. The documentary gave parents an insight into what children in UK schools were eating, along with the fact that schools were paying only 36 pence per child per meal, which was much less than parents were paying schools for the meals. Government responded by making a commitment to transform school nutrition, and set up the School Meals Review Panel in 2005 (SMRP) (DfE, 2010).

1.6 History of School Nutrition Provision in Britain

School meal provision dates back over 100 years, as early as 1879, Manchester, Bradford, London and other school boards began to provide free school meals to undernourished children, as they had recognised the link between hunger and failure to learn (Gillard, 2003). The lack of healthy young men available to volunteer to serve in the 1899 Boer War brought recognition of the level of undernourishment in the UK. This led to the birth of the 1906 Education Act; which would provide a subsidised school meal service enabling children to take advantage of the education provided (James, 2004). Following the Second World War, the 1944 Education act was born in response to continued concern regarding the health of the nation. This placed a statutory duty on Local Education Authorities (LEA's) to provide school meals for all who wanted them at a standard set price, and that would meet the needs of growing children and the nutritional guidelines put in place (Rona *et al,* 1983). From 1947, the school meal service was supplied free to all children, with Government grants to LEA's covering 95% of the total cost (The Caroline Walker Trust (CWT) 2005). Nutritional standards for schools were updated in both 1955 and 1975, following the Committee on Medical Aspects of Health (COMA) report on diet (DH, 1974).

The last three decades have seen many changes in school nutrition provision in the UK, and not all beneficial to child health. The 1980 Education Act brought substantial changes to nutrition provision in schools. A change of Government called for a reduction in public spending as net expenditure on school meals was over 400 million per year in 1980 (Davies, 2005). School nutrition provision was relegated to a non-essential service; this led to the removal of fixed standard pricing and the abolishment of nutritional standards. LEA's were only obligated to provide meals to those entitled to free school meals, but not to others. Some LEA's dismantled their school services completely, and provided sandwiches to those entitled to free school meals (Davies, 2005).

The Local Government Act 1988 saw the introduction of Compulsive Competitive Tendering (CCT), requiring all LEA's to put school meal services out to tender. The basic principle of this decision was to offer the contracts to the lowest bidder, and LEA's were obliged to take the lowest bid without any consideration of nutritional quality (Evans & Harper, 2009). Unison 2005 believed that the move towards CCT led to the loss of school kitchens and a skilled work force, and increased the provision of processed foods. Since the abolishment of Nutritional standards in 1980, school meal uptake has continually decreased, to a level as low as 39.3% in 2008-2009. One explanation for this is that many parents have increasingly viewed packed lunches to be more nutritious and better value than school meals for their children (Gillard, 2003, SFT, 2009). Since the abolishment of nutritional standards in 1980, extensive research has been undertaken, which reported that school meals were less than adequate nutritionally. Nelson & Paul 1983 conducted a dietary analysis of a 191 primary and secondary school children, to investigate the nutritional contribution of school meals to a child's total daily nutrient intake. Findings showed that school meals provided less than a quarter of the DRV's for energy and less than a third of the DRV's for protein, calcium, iron and thiamine. It was noted that total nutrient intakes were lower on school days when compared to weekends; however children of lower socioeconomic status obtained a larger proportion of their daily nutrient intake from school meals (Nelson & Paul 1983).

In 2001, the DH introduced the School Fruit and Vegetable Scheme (SFVS), this aimed to provide two million school children aged 4-6 years with free snack of fruit or vegetable on each school day (NSFS, 2000). A study by Jefferson and Cowbrough 2004, reported that the effects of the fruit and vegetable scheme had been positive, suggesting an increase in the intake of fruit and vegetables for both the children involved and their families. In 2005, a further £77 million was committed to the SFVS (SMRP, 2005).

However continued concern regarding the standards of school meals and the deterioration of children's diets, led to the re-introduction of (Nutritional Standards for School meals) Regulations in 2001, the first in over twenty years (Nelson 2006). The Department for Education and Skills 2000 DfES set out minimum nutritional standards, with effect from 2001, with a recommendation that they meet the nutritional guidelines set by the (CWT, 1992). Nutritional Standards were based on five food groups, food types and frequency were specified, rather than nutrient content, (DfES, 2001).

- Fresh fruit or tinned fruit, available daily.
- A fruit based desert, available at least twice a week.
- A type of vegetable (not starchy carbohydrate), available daily.
- Red meat, available at least twice a week.
- Fish, available at least one day in any week.
- Fat or oil, not to be used on starchy food more than three days.

(The Education (Nutritional Standards for School Lunches, Regulations) (England) 2000).

The establishment of these very basic food based standards (FBS) led to a varied response from schools, for example the requirement that red meat had to be available twice a week did not include any requirements regarding the nutritional content. A nutritional analysis of primary school meals was undertaken by The Soil Association in 2004, results showed that children who ate the school meals for five consecutive days would consume 28% more saturated fat and 40% more sodium than the nutritional guidelines recommended. Furthermore, micronutrients iron and zinc were up to 30% below the recommended intake. The lack of enforcement of these very basic FBS meant that low cost, poor quality meals could be served regardless of nutritional content (National Union of Teachers, (NUT), 2004).

A secondary analysis of the 1997 NDNS of children aged 4-18, which compared school food consumption with 2004-2005 was conducted to investigate the contribution of the school meal to daily nutrient intakes. Findings showed that school meals typically failed to offer the nutrients needed as part of a balanced daily diet, and that foods consumed outside school were unlikely make up for the deficit in nutrients. They reported that the average school meals were high in fat, sugar and salt and lower in micro-nutrients (Nelson *et al*, 2007).

Nelson *et al*, 2006, undertook a national survey on behalf of the FSA and DfES, to assess the LEA's compliance with regards to Nutritional standards (DfES, 2001), in English primary schools. Findings confirmed that of the total 146 schools included in the survey, 112 failed to comply with compulsory guidelines, only 23% of primary schools were meeting the required National Nutritional Standards (Nelson *et al*, 2006). However, Nelson *et al*, 2006 reported that the issue regarding school meals was double sided, as it was not only the quality of food being provided but also what was being chosen. It was reported that the most popular food choices among children were cakes, biscuits and ice cream and that less than 50% of the meals consumed by children met Nutritional Standards. It was suggested that this may be because there was no system in place for monitoring food choice as well as nutritional quality (Davies, 2005).

Another study by Rogers *et al*, 2007 investigated the quality of food consumed in English primary schools. It was reported that both the meals supplied by the school and the meals prepared at home failed to meet nutritional standards, though the meals provided by the school performed better. However for both meal choices, intakes of energy, calcium, iron, zinc, iodine and riboflavin were too low, whereas intakes of total fat and saturated fatty acids were too high. Secondly it was reported that less than 50% of the recommended amount of fruit and vegetables were consumed by children, eating either the school or home prepared meal.

In response to research (Nelson *et al,* 2006), and the mounting public pressure, the DfES established the School Food Trust (SFT, 2006), to provide independent advice and support to LEA's regarding the education and nutritional health of children (Sorhaindo & Feinstein, 2006). The SFT were given the challenge to improve nutrition provision and nutrition skills in schools, with the aim to promote the education and health of children (Nelson, 2011). At the same time, the DfES established the School Meals Review Panel (SMRP), 2005. Their task was to revise existing minimum standard, using the CWT guidelines as a starting point, and develop and recommend new robust National Nutritional Standards to the DfES to improve School nutrition provision (SMRP, 2005).

Recommendations by the SMRP and SFT (Turning the Tables: Transforming School Food, report, 2005), led to the new National Nutritional Standards which were announced in 2006 (Nutritional Standards and requirements for School Food (England) Regulations, 2007). This report strongly recommended nutrient based nutritional standards, and subsequently in 2006, a combination of the 2001 FBS and the new nutrient-based standards recommended by the SMRP were released. These combination standards for school meals were designed ahead of the introduction of nutrient based standards. In 2007 the Government's nutrient-based and final food-based standards were published, and were also updated in 2008. All primary schools had to comply with regulations by 2008, however schools were encouraged to adopt the new Government nutrient based standards (GNBS, 2007), before they became law (The Education (Nutritional Standards and Requirements for School Food) (England) Regulations 2007), (Brennan, 2007).

Following the implementation of the new GNBS, 2007, a study by Haroun *et al,* 2010, suggested that food choice and nutrition provision in primary schools has improved. A random sample of 6696 children from a 136 England primary schools who were consuming school meals, were selected. School meal provision in 2009 was assessed and compared with similar data collected in 2005. Findings showed that primary schools in 2009 provided considerably more fruit, vegetables and salads compared with 2005 schools. Haroun *et al*, 2010, reported that though school meal provision had generally improved, some micronutrients were still below GNBS, 2007. However, Adamson *et al*, 2012 reported that school meal uptake has increased year on year. Findings showed a net uptake of 46.3%, in 2011-2012, which is also a 2% increase on 2010-2011, a substantial increase when compared to an uptake of 39.3% in 2008-2009.

To help apply the new compulsory GNBS, a transitional £220m School Lunch Grant (2005-2008) was put in place. This was to be made available to LEA's, to help them meet the new GNBS and increase school meal uptake whilst keeping the price down. In 2006, a new School Lunch Grant of £240m to help continue improvements (DfE, 2010). From 2005-2011, these Government School Lunch Grants were ring-fenced, with specific conditions as to how the funding could be used. However from 2011, Government removed the ring-fence from the funding for school meals (Gillie & Long, 2011). School funding for school meals is still available, however it is to be revised and will be available via dedicated School Grants (School Funding, 2011-2012). Government have suggested that this will allow schools to make their own decisions; however schools will need to be more flexible with regard funding and Government grants (School Funding, 2011-2012).

1.7 Timeline

1906 — Education Act: LEA's were empowered to contribute and provide a subsidised school meal service, which would enable children to take advantage of the education provided. However, they were not compelled to do so, this meant that the provision of school meals varied between LEA's, and some children were overlooked (James, 2004).

1944 — Education Act: was born in response to continued concern regarding the health of the nation. This placed a statutory duty on LEA's to provide school meals for all who wanted them at a standard set price.

1947 — The school meal service was supplied free to all children, with Government grants to LEA's covering 95% of the total cost.

1955/ 1975 — Nutritional standards for schools were updated following the Committee on Medical Aspects of Health (COMA) report on diet (DH, 1974).

1980 — The 1980 Education Act: LEA's were only obliged to supply school meals to those entitled to free school meals. Fixed pricing, nutritional standards and entitlement to free school milk was removed.

1988 — The Local Government Act 1988: saw the introduction of Compulsive Competitive Tendering (CCT), requiring all LEA's to put school meal services out to tender.

1992 — In response to the Government White Paper on the Health of the Nation DH, 1992, The Caroline Walker Trust (CWT) Nutritional Guidelines were introduced by the DfES, and were also updated in 2005.

2000 — Minimum nutritional food based Standards for schools were re-introduced using the nutritional guidelines set by the CWT, to be made compulsory by 2000 – 2001.

2001 — School fruit and Vegetable Scheme was introduced, children aged 4-6 were given a free piece of fruit or vegetable every school day to support the promotion of healthy eating.

2005 — 2005 was a major turning point for school food provision with three key developments that year:

- The broadcast of Jamie Oliver's 'Jamie's School Dinners' attracting attention at both public and Government levels (February).
- The DfES established the School Meal Review Panel (SMRP) to advice on a major revision of current school meal standards.
- The establishment of the School Food Trust with the remit to 'transform school food'

2006 — Interim Food Based Standards for school meals.

2007 — Nutrient-based and final food-based standards were published.

2008 — Primary schools had to meet Nutrient Based Standards for school meals, by law.

1.8 The importance of nutrition for learning

1.8.1 Cognitive development and nutrition

The oxford dictionary defines cognition as 'the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses' (www.**oxforddictionaries.com/definition**/english/**cognition**). Cognitive development in children, on the whole basically follows the same path; however individuality such as biological makeup and environmental experiences will create slight differences in the developmental path (Oakley, 2004). There is little doubt regarding the importance of a healthy balanced diet and the cognitive development in childhood, and that severe malnutrition in childhood can adversely impair cognitive development. The brain will fail to function properly without the correct nutrition, as neurotransmitters are synthesized from compounds which are provided by the diet (Blass & Gibson, 1999). Deficiencies in iron, vitamin A, iodine, B vitamins, zinc and other nutrients frequently affect millions in developing countries (Christian & West, 1998), however, though easily preventable, micronutrient deficiencies are still causing irreversible damage to health of children. For example, iodine deficiency is one of the most easily preventable causes of brain damage in children, serious iodine deficiencies during pregnancy can lead to grave irreversible forms of mental retardation in children and even cause stillbirth (WHO, 2013).

Research has shown that even mild to moderate undernutrition can have lasting negative effects on cognitive development (Duggan *et al*, 2008) (Brown & Sherman, 1995), however it has also been suggested that optimum nutrition can have beneficial effects on cognitive function, 'performance and behaviour' (Hoyland *et al*, 2008). Research regarding the relationship between nutrition and cognitive function is become increasingly recognised, a review of research by Scrimshaw 1998 concluded that even slight under-nutrition may effect psychomotor development; he suggests that under-nutrition decreases activity levels, social interactions and cognitive functioning. Simeon & Grantham-McGregor,1990 undertook a review of fifteen studies of mild to moderate malnutrition, findings showed that only one study reported that nutritional status was not associated with cognitive development.

Some studies have shown an impact of multivitamin and mineral supplementation on cognitive function. Benton & Cook, 1991 undertook a clinical study testing the effects of a multivitamin on IQ, in which 47 British school children were randomly assigned to a multivitamin or placebo group for six to eight weeks. Non-verbal IQ tests reported a 7.6 point increase for multi-vitamin group and a 1.7 point decrease for the children in the placebo group. Interestingly, other studies highlighted that only those children from a lower socio-economic group with a micronutrient poor diet, showed a positive response to multi-vitamin supplementation (Crombie *et al,* 1990).

One extensively studied area is the relationship between iron deficiency and cognition. The brain has high iron content, and brain function is negatively influence by iron deficiency (Hallberg *et al*, 2004). The Food and Health Forum, 2008, presented evidence which suggested a relationship between iron deficiency anaemia (IDA) and cognition. Belot & James, 2011, suggest that IDA in children aged between (5 and 18 years) can have an impact on the central nervous system (CNS), which has been shown to lead to cognitive and behavioural problems (Gesch *et al*, 2002). A study review by Grantham-McGregor & Ani 2001, on iron deficiency and cognitive development, indicates that children with IDA continue to have poor cognition and more behavioural problems throughout childhood.

1.8.2 Short Term Hunger and Cognition

Duggan *et al*, 2008, suggests that children's nutritional needs are high compared to their size and that a poor diet can lead to a deficit in nutrient availability throughout the day. A small number of studies have investigated the relationship between cognitive function and nutrition with relation to short term hunger in children (Benton, 2001). Research has reported that children between the ages 4-10 utilise cerebral glucose at double the rate of adults (Chugani, 1998). Furthermore, it was recognised that age related changes in cerebral glucose utilisation happen around the same time as various cognitive skills and behaviours occur in children. A study by Benton *et al*, 1987 investigated the impact of glucose on cognitive function and concentration in children aged 6-7 years. Children consumed lunch at 12.30-13.00 and received either a glucose drink or placebo at 14.30, and testing followed at 14.45. Children were tested using a television game, in which they had 15 balls and they had to stop them passing across the screen (Shakow, 1962). Findings showed that glucose ingestion led to a faster reaction time compared to placebo, furthermore children who had received the glucose drink found it easier to concentrate. A more recent study by Benton & Stevens, 2008, again investigated the impact of glucose on cognition, 'behaviour, attention and memory'. Children aged 9-10 years consumed either a glucose drink or placebo, and were tested for picture recall, spatial memory and behaviour. Findings showed that children recalled significantly more pictures following the glucose drink. However, the glucose drink had no effect on spatial memory and attention but children did spend more time on task following the glucose drink.

The majority of studies investigating the relationship between short term hunger and cognitive function have examined the impact of breakfast consumption. It is suggested that cognitive performance is enhanced after eating breakfast compared with no breakfast control (Michaud *et al,* 1991). A review by Pollit *et al*, 1998, compared the findings of three studies 'two involved well nourished children and the third involved children at nutritional risk', and all explored the effects of short term hunger on attention and memory function in children aged 9-11. Glucose and insulin levels were measured and cognitive tests were undertaken in fasting and non-fasting conditions. Results showed that short term fasting (missing breakfast) had a direct impact on cognitive function; the effect of fasting were increased errors and slower memory recall. Pollit *et al,* 1998, suggested that these results were due to metabolic stress, in which homeostatic mechanisms struggled to maintain circulating glucose concentrations.

Another study by Wesnes *et al*, 2003, investigated the impact of breakfast in children aged 9 to 16 years. Children were given a different breakfast type for four consecutive days, shreddies, cheerios, a glucose drink or no breakfast. On each day children completed a series of computer tests measuring attention and memory, tests were undertaken at different times, once before breakfast, and again at 30, 90, 150 and 210 minutes after breakfast. Findings revealed that children who had consumed either cheerios or shreddies had performed significantly better on memory tests than those who consumed either a glucose drink or nothing. These findings support the suggestion that eating complex carbohydrates such as cereals, release sugars slowly to feed the brain. But simple carbohydrates such as glucose drink, release sugar quickly into the bloodstream which can cause a burst in energy. However this quick release of sugar can also cause a greater release of insulin, which can lead to drowsiness and difficulty concentrating.

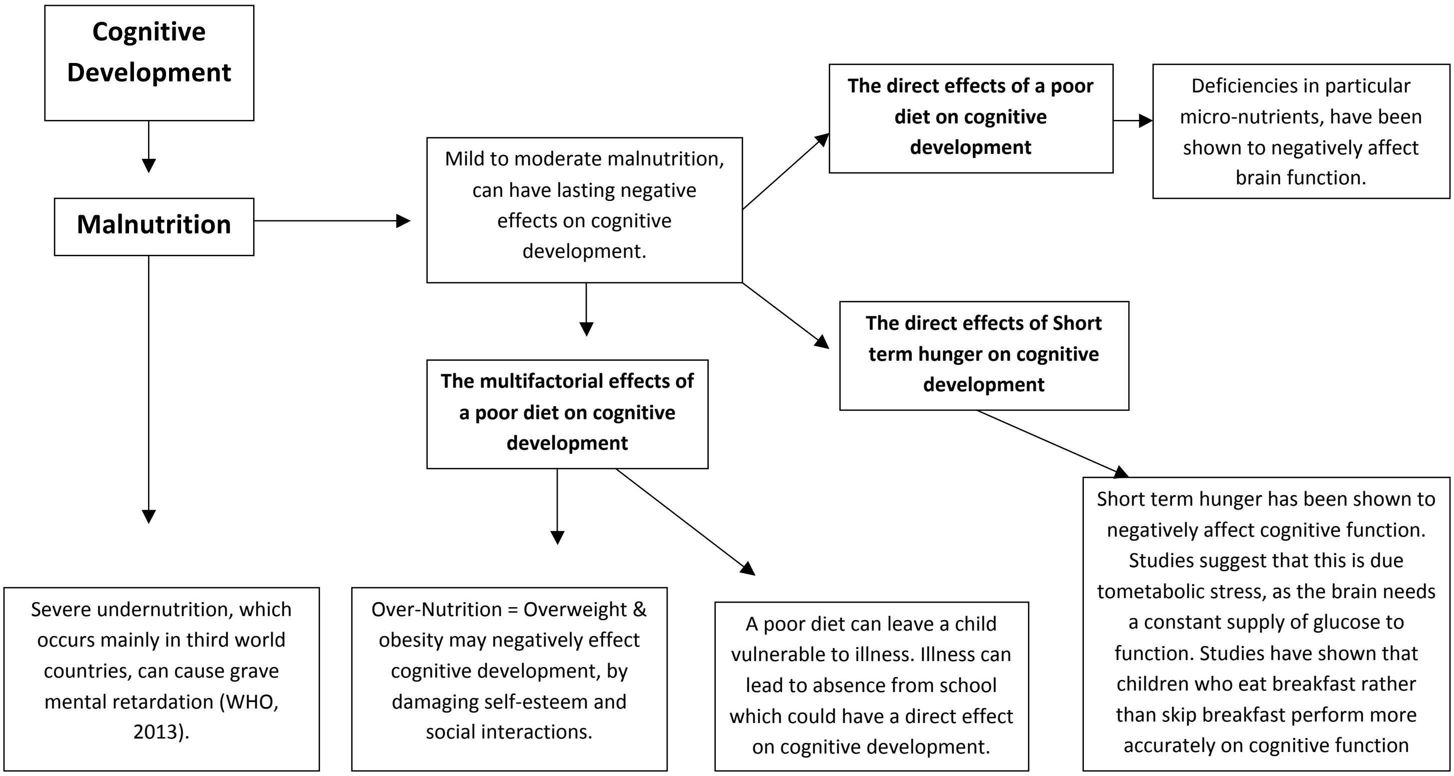
Generally breakfast consumption is considered to have a positive effect on cognitive function; however there is a growing body of research investigating the relationship between a mid-morning snack and cognitive function. Snacks have often been viewed as unhealthy because most are conveniently purchased outside the home, and can often be high in fat and sugar (OFCOM, 2004). Following the introduction of the National School Fruit Scheme (NSFS, 2000) infant children are supplied daily with a free piece of fruit or a vegetable in primary schools. An evaluation of the scheme revealed that in 55% of schools, teachers reported an improvement in the ethos and atmosphere in the classroom, 19% of schools reported a positive effect on children's attention and 18% of schools reported a positive effect on children's ability to settle and overall behaviour (DH, 2001). The Food Commission, 2001, held a Children's Nutrition Action plan, where by The National Heart Forum, put forward a recommendation that the (NSFS) be extended to all primary school children (The Food Commission, 2001), to date this has not been put into place. This maybe because the Food Standards Agency (FSA) reviewed a series of studies investigating the relationship between nutrition and educational benefits, the review concluded that due to the differences in their design, and lack of quality evidence, the findings were inconclusive (Ells *et al*, 2006).

1.8.3 Multifactorial Effect of Diet on Cognitive Development

Belot & James 2011 suggested that the link between nutrition and education is multifactorial. There could be other stressors that may affect the cognitive development of children from low-income families, such as poor housing, sanitation and inadequate care (Grantham-McGregor *et al,* 2005).

A review by Sorhaindo & Feinstein, 2006, identifies different channels as to how a poor diet may impact on educational outcome. Firstly, it is suggested that a poor diet can leave a child vulnerable to illness, this leads to absence from school which may therefore have a direct effect on educational outcome. Because a balanced diet which is sufficient in vitamins and minerals, will counteract infections that are easily contacted when children are grouped together. Secondly, obesity related to poor nutrition can cause physical handicap, limit peer acceptance, damage self-esteem and cause children to feel socially excluded. Social exclusion in the school environment leads to under-achievement and can impact on cognitive development (Poskitt & Morgan, 2011). Possible routes are shown in Figure 1.1.

Figure 1.1 -The routes to which cognitive development and function may be effected by Malnutrition



1.9 Research aim

The aim of this study was to undertake an investigation into the provision of school nutrition in primary schools, concentrating on the county of Lancashire. This study has three main objectives:

1. To undertake an analysis of the food provided by LCCG, to primary schools in Lancashire, and compare the findings to GNBS, (2007).

2. To assess whether school meals have improved nutritionally since 2002.

3. To investigate the impact of a mid-morning snack on a child's cognitive function (concentration and memory).

1.10 The County of Lancashire

Lancashire is made up of 12 county districts; with a varied landscape and abundant countryside. There is a diverse population of around 1.4 million people, with a considerable variation in levels of socioeconomic status. The population of Lancashire is relatively young, as 24% are under the age of 19 years, compared to a national average of 23.9% (Chi Mat, 2013). However Lancashire also has an increasing elderly community, as people are living longer (LCC, 2013). Lancashire performs slightly better with regards to levels of child poverty, as 18.4% of children under the age of 16 live below the poverty line compared to 21.1% nationally. However the health and wellbeing of children in Lancashire is worse than the National average, as both the infant and child mortality rates are higher than the national average (Chi Mat, 2013). Child obesity rates in Lancashire 2012 continue to rise, 9.6% of reception children aged 4-5 years are classified as obese compared with 9.5% nationally; this has increased from 9% in 2011. The prevalence of overweight for children aged 4-5, was also significantly higher than the national average. Obesity rates almost double for year six children compared to reception children. 17.5% of children aged between 10 &11 years are classified as obese in 2012; however it is lower than the national average at 19.2%. The prevalence of overweight for children aged 10-11, is also slightly lower than the national average. Educational outcomes in Lancashire are in line with the national average, 59.9% of children achieve five or more GCSE's at A*-C, grade, including Maths and English. Children in Lancashire are more likely to be admitted to hospital for long-term conditions, compared with the national average (NHS, Aqua, 2012). Further to this, child hospital admissions for alcohol specific conditions and injuries are both much higher than the national average (ChiMat, 2013).

1.11 The Lancashire School Meal Service (Lancashire County Council Group)

LCCG, provide a total of 525 primary schools in Lancashire with school meals. Two school menus are provided, 'Fresher plus' which is suitable for schools which do not have cooking facilities, and 'Cook Servery' suitable for schools with a full functional kitchen. School meals are supplied in the form of a three week rolling menu with three daily choices. LCCG, are part of the Lancashire Healthy Eating Development Group, formed to develop nutritional policy for schools in Lancashire. LCCG use characters to promote healthy eating, for example 'Healthy Heroes', which are also integrated into the school educational programmes. Produce is sourced locally where possible, for example potatoes are grown in Lancashire and fresh yogurt is produced in Lancashire, milk and eggs are also sourced locally.

1.12 Moss Side Primary School, Lancashire

Moss Side Primary School has been selected as the setting for this study as a representation of primary schools in Lancashire. This is average sized school almost all the children are White British, from wide range of social and economic backgrounds. The proportion of children eligible for free school meals at 16% is below the National average at 19%. Standards are consistently high with results well above the national average, for example for Mathematics Moss side achieved 100% pass rate at key stage 2 level 4 compared the a National average of 80% at Level 5, 44% compared to the National average of 35% and at level 6, 6% compared to the National average 0%. In their last Ofsted report, they received a consistent grade 1 'Exceptionally and Consistently High grade' (Ofsted, 2009).

CHAPTER 2

METHODS

2.1 Overview of Methodology

In this chapter the methods and materials used in order to meet the aims and objectives of this study have been described in three main parts. Section 1, provides a description of the methods undertaken in the school setting selection, Laboratory analyses and Nutrient database analysis, in order to analyse Lancashire school meals, and discover how they compare to GNBS, (2007), as displayed Table 2.1. Section 2, explains the methods involved using Windiets nutrient database (WND) in the analysis of 2012 and historic 2002 school meal menus. Section 3, describes the methods undertaken in, recruitment of children, testing, scoring and data analysis, to investigate the impact of a mid-morning snack in primary school on children's concentration and short term memory.

Table 2.1 - Government Nutrient Based Standards 2007

Energy or Nutrient and amount of Measurement	Maximum or Minimum Value	Recommended Values for Primary School meals
Energy in kilojoules and (kilocalories)		**2215 ± 5% (111) (530) ± 5% (26.5)**
Carbohydrate (g)	**Min**	**70.6**
Fat (g)	**Max**	**20.6**
Saturated Fat (g)	**Max**	**6.5**
Non-milk extrinsic sugars (NME)(g)	**Max**	**15.5**
Protein (g)	**Min**	**7.5**
Fibre (g)	**Min**	**4.2**
Sodium (mg)	**Max**	**499.0**
Vitamin A (µg)	**Min**	**175.0**
Vitamin C (µg)	**Min**	**10.5**
Folate (µg)	**Min**	**53.0**
Calcium (mg)	**Min**	**193.0**
Iron (mg)	**Min**	**3.0**
Zinc (mg)	**Min**	**2.5**

2.2 Reasons for choice of Methodology

Two different methods were used to determine nutrient composition of the school meals, laboratory analyses and nutrient database analysis. Firstly, the use of two different approaches to food analysis was primarily because research has shown that there can be statistical differences between data obtained from laboratory investigations and nutrient database analysis (Weber & Morais, 2010). Further to this, the second objective of this study required the analysis of a historic 2002 school menu, for this a nutrient database analysis was appropriate.

The method used to assess cognitive function (concentration and memory) was a version of Kim's game. This short term memory game is commonly played with children; it is a simple procedure so it could be undertaken in a short time, and was also easily adapted so a group of children could be tested together (www.educationscotland.gov.uk/studyskills/kimsgame/index.asp).

2.3 School Meal Analysis

2.3.1 Study participants

One Lancashire primary school was selected (Moss Side Primary School, Leyland, Lancashire) with a population number of 250 children aged between 4 and 11 years. This primary school was chosen as a representation of 525 primary schools across Lancashire, who receives the same nutritional provision from LCCG. Consent was obtained from the head teacher of Moss Side Primary School, Leyland Lancashire (As shown in Appendix). Ethical approval was sought from and granted by Ethics Committee Built, Sport and Health (BuSH), University of Central Lancashire.

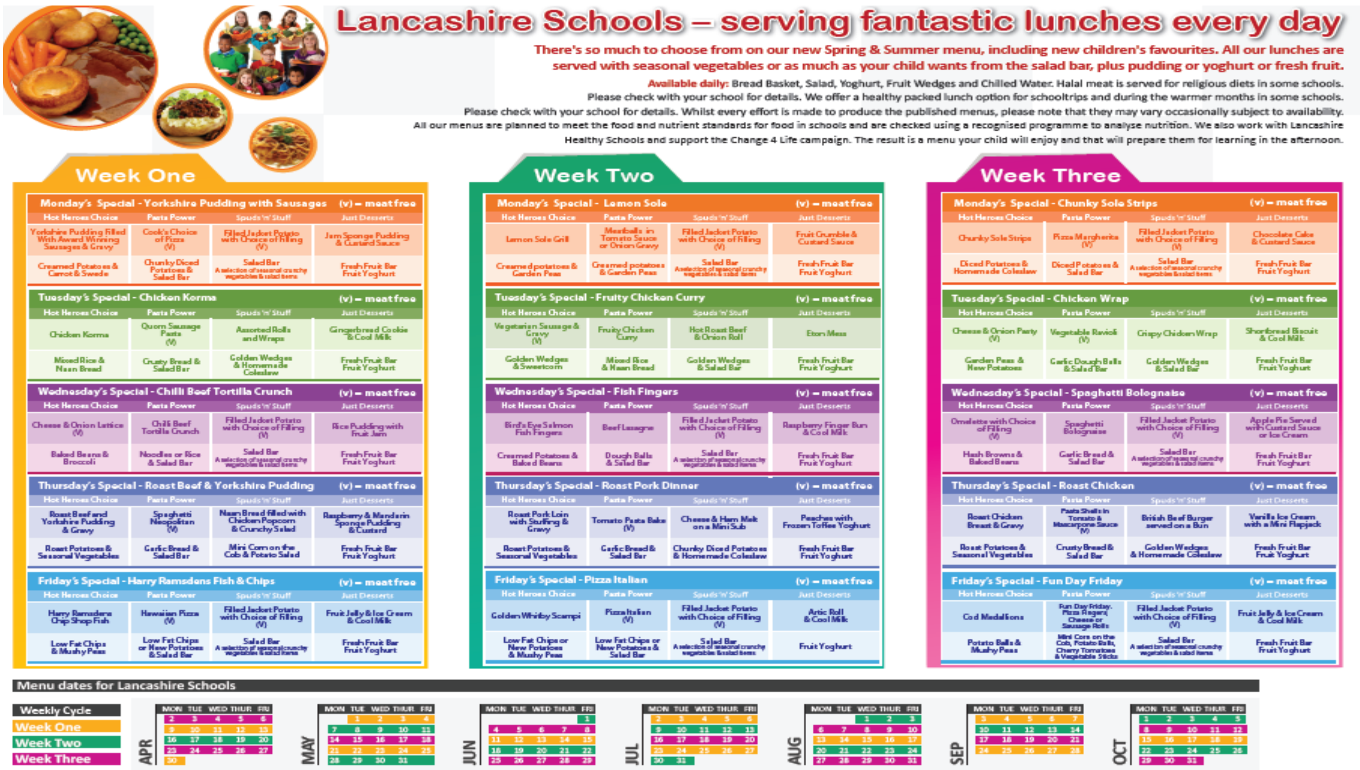
2.3.2 Lancashire County Council Commercial Group.

LCCG, work with nutritionists and use the industry recognised computer software system CRISp (info@crispsystems.com) so that menus are provided which aim to comply with GNBS. (www.**childrensfoodtrust.org.uk**/assets/sft**nutrition**). LCCG, provide two school menus, 'Fresher plus' which is suitable for schools which do not have cooking facilities, and 'Cook Servery' suitable for schools with a full functional kitchen (www.servinglancashire.org.uk).

2.3.3 LCCG, Nutrition Provision.

School meals are supplied in the form of a three week rolling menu with the choice of three meals and three deserts. The menu used for this study, was available to schools from April to October 2012, as shown Figure 2.1

Figure 2.1 - 2012 April – October LCCG School Menu



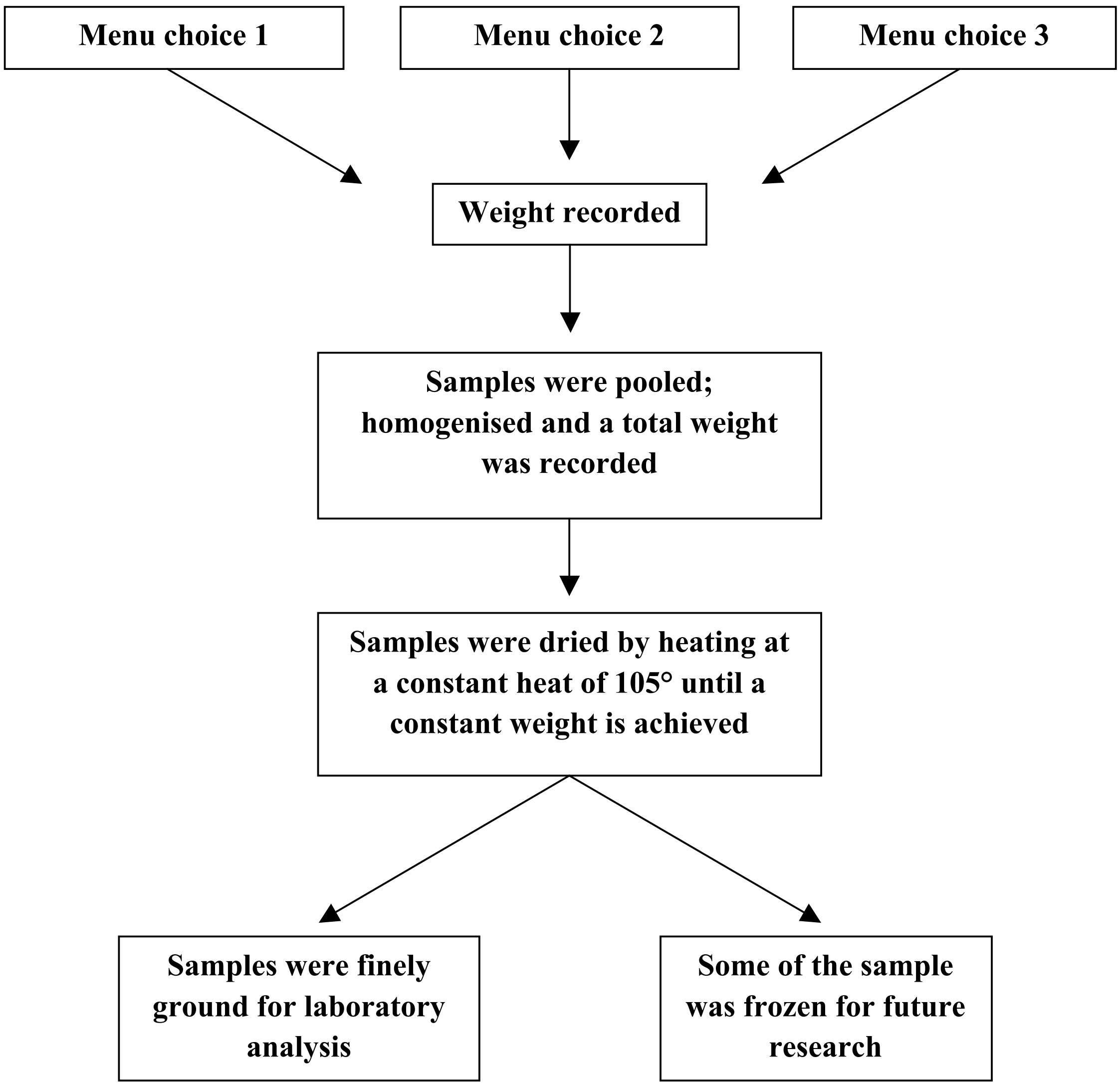
2.4 School Meal Collection

Collection commenced, 10th September 2012, three whole meal samples (main meal and dessert) where collected daily from the kitchen servery, (which was a total of 45 meals). Meal collection continued for three consecutive weeks and three daily menu choices where extracted randomly from a selection of meals which had been pre-served for children to collect. This method of randomisation was used to avoid any threat to external validity, as the school knew they were participating in the study, meals that were served specifically for analysis may not have been a true reflection of their daily meal (Campbell & Stanley, 1963).

2.5 School Meal Sample Preparation

A total of 45 meal samples were weighed individually to the nearest .05 grams, using digital kitchen scales (Salter, Ho-Medics, Group Ltd) and portion size was recorded (beverages not included). All three daily menu choices were carefully homogenised in a steam cleaned bowl to avoid any contamination, a blender (Bosch, Home appliances ltd) was used to attain a homogenous sample which could be analysed to achieve a daily average, the collection of 45 meals, resulted in a total of 15 daily average sample meals. The moisture content of the food samples was measured by heating the samples to 105°C and then re-weighing every hour until a constant weight was attained, as shown in figure 3.

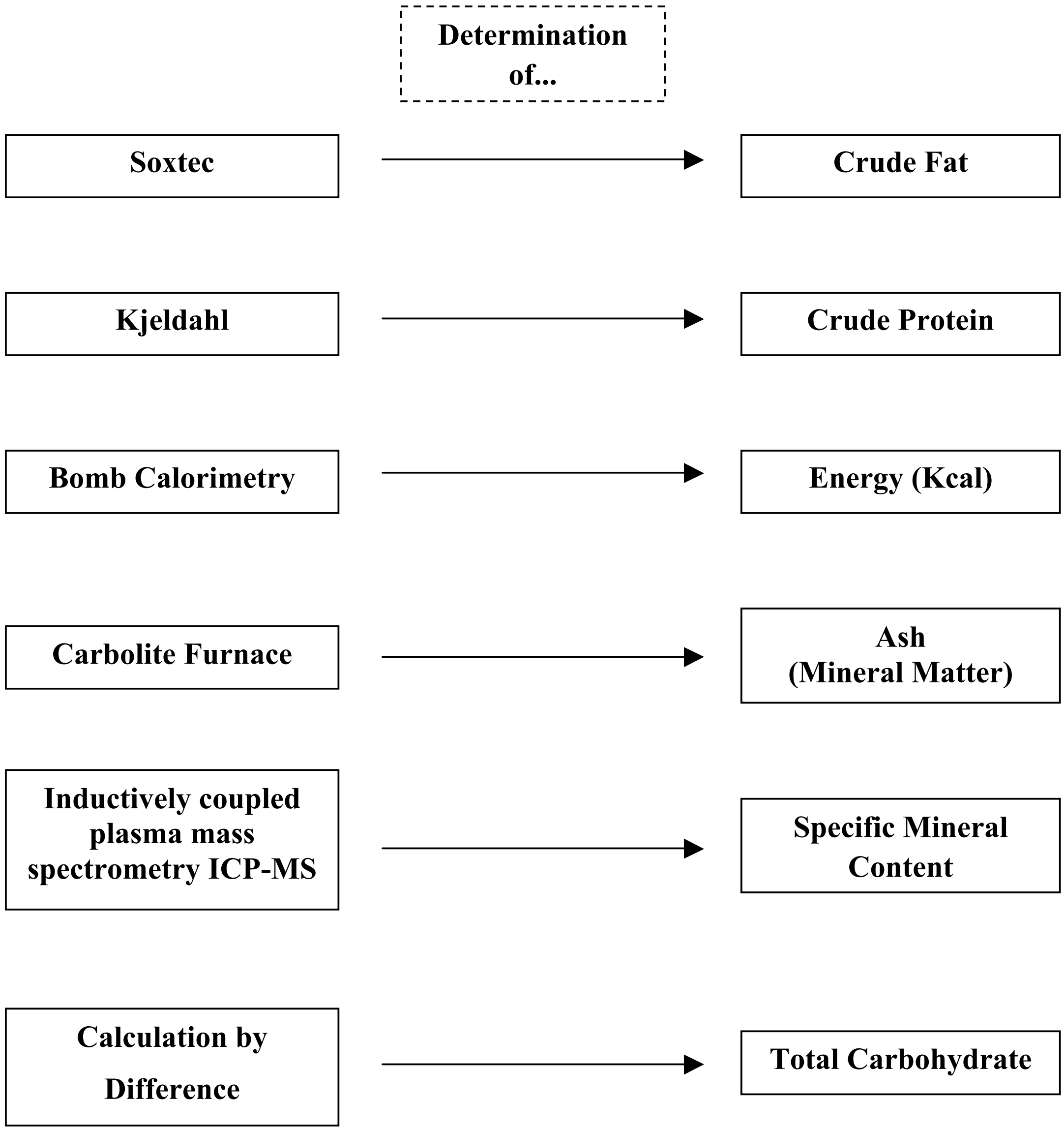
Figure 2.2 School Meal Collection and Preparation



2.6 Laboratory Analysis of School Meals

A selection of chemical analyses were undertaken to assess the nutritional content of the sample 'average daily meals' which had been collected over three consecutive weeks, (15 average daily meals in total). The samples were transported to the laboratory labelled and stored in a laboratory refrigerator (New Brunswick scientific). Each sample was ground to homogeneity with an analytical Mill (IKA, A11 Basic Analytical Mill), and this resulted in a representative sample for chemical analysis (Bailey *et al*, 2006).

Figure 2.3 Laboratory Tests Used for Analysis of School Meals



2.6.1 Determination of fat (Soxtec)

The crude fat was extracted using the soxhlet method of crude fat extraction (Weber & Morais, 2010). Six replicate 2g samples of each meal sample (1-15) were measured accurately into extraction thimbles (Whatman Ltd) using an analytical balance (OHAUS, Pioneer Scales). Aluminium solvent containers were weighed accurately before adding 40ml of petroleum ether. Both thimbles and aluminium containers were carefully fixed onto the Soxtec system, and the samples are lowered into the boiling solvent to allow extraction to proceed. After 30 min's the thimbles were raised up and suspended over the boiling solvent to continue collection of any residual traces of extractable crude fats. During the last step of crude fat extraction, the condenser taps were closed and the air pump was switched on to allow the evaporation and removal of solvent, leaving a concentrated crude fat extract. Aluminium containers were then re-weighed using an analytical balance, and the gain in weight was recorded. The accuracy of analysis was measured by replicate analysis in batches of six, this was undertaken to identify any variation between results.

Sample calculation 2.1 -

$$\% \text{ fat} = \frac{\textit{End Weight}}{\textit{Initial Weight}} \times 100$$

2.6.2 Determination of crude protein (Kjeldahl)

The Kjeldahl allowed the calculation of protein, the Kjeldahl is the standard method of nitrogen determination; the food sample is digested with concentrated sulphuric acid, so the nitrogen is released and then the nitrogen is determined by titration. The amount of protein in the sample is then calculated from the nitrogen concentration of the sample (Weber & Morais, 2010). Glass sample tubes were rinsed thoroughly with epure water. Three replicate 1g samples of each meal sample (1-15), were measured accurately into glass sample tubes using an analytical balance (OHAUS, Pioneer Scales). Samples were digested in concentrated sulphuric acid with a catalyst, (selenium) at temperatures between 340 and 370°C. Selenium was used because of its short digestion time, along as the temperature was below 390°C, because nitrogen losses can occur above this temperature. Once samples were digested and cooled, they were diluted with 70ml aliquot of distilled water. A distilled water blank was run at the start of each analyses batch, and the value obtained and subtracted from each sample. Glass tubes containing digested samples were then transferred to the Kjeldahl distillation apparatus, to allow determination of crude protein (www.buchi.com, Concklin- Brittain *et al*, 1999). The accuracy of Kjeldahl was measured by replicate analysis, with a total of five replicate samples, this was undertaken to identify any variation between results.

Sample calculation 2.2 -

$$\%N = 0.14 \ \frac{V}{W}$$

If N is the nitrogen content, V is the volume (mL) of 0.1 M HCI used and W is the weight of the food (g)

The nitrogen content of protein is 16% therefore the amount of protein in the sample is 100/16 % N = 6.25 x % N

Therefore, $\textbf{\% Protein} = \mathbf{0.875} \ \frac{V}{W}$

2.6.3 Determination of energy (Bomb Calorimetry)

Determination of energy was undertaken using Bomb Calorimetry (6200 Calorimeter Operation, Parr Instrument Company). Oxygen bomb calorimeters are the standard laboratory instrument for measuring calorific values of solid combustible samples. The gross heat of combustion of each sample is released and heats the water and the temperature change is recorded (Parr Instrument Company). An internal standard (benzoic acid) was used to determine the Thermal Capacity of the instrument before each sample batch. Samples were accurately measured in triplicate to the nearest 1g, using an analytical balance. Each sample was then carefully loaded into the head of the Bomb cylinder; a 10cm fuse wire was the attached and positioned so to just touch the sample. The Bomb head was then carefully loaded into the cylinder and tightened securely, before the Bomb was filled with oxygen to 25 ATM. The Bucket which sits in the calorimeter was filled with 2 Kg of distilled water, it was critical that this measure was repeated for every sample, and placed into the calorimeter. The bomb was then placed and attached to ignition wires, before the lid was carefully closed and determination of energy could proceed. Energy is determined by the measure of adiabatic heat that each sample releases. The accuracy of Bomb Calorimetry was measured by replicate analysis, a total of ten replicate samples, and this was undertaken to identify any variation between results.

Sample calculation 2.3 -

$$\textbf{Energy content (j/g)} = \frac{\text{TC x Temp.Rise}}{Weight}$$

TC = thermal capacity in joules per °C temperature rise.

W = weight of sample in grams.

2.6.4 Determination of Ash (mineral matter)

Ash is the term used to represent the dry inorganic matter, the mineral content of the sample. Triplicate 1.5 gram samples were measured accurately into crucibles using an analytical balance. Each crucible was marked before the samples were carefully placed into the Carbolite furnace, making sure the order of samples was recorded. Samples were then heated at a temperature of 650°C over night. After cooling, the weight of the residual matter was recorded and retained for determination of specific mineral content.

2.6.5 Determination of specific mineral content (Ash extraction & ICP MS)

Calcium (Ca) sodium (Na) and iron (Fe) were determined using previously ashed samples. Specific mineral content of ashed samples was determined using inductively coupled plasma mass spectrometry (ICP-MS) (Thermo, (X-Series), Thermo Fisher (Inc, VG). 50% v/v HCI was warmed on a hot plate. Using pipettes, and pipette tips, 5x5ml aliquots (25ml total) were added repeatedly to the crucible and ash sample and poured through a funnel into a volumetric flask making sure the entire sample was extracted from the crucible. The sample was then diluted with epure water to a final volume of 100ml. 100μL of sample were added to 9890μL of 1% Nitric acid and 10μL of internal standard 115 ppm (Indium). Samples were then aspirated by ICP-MS (Thermo, (X-Series), Thermo Fisher (Inc, VG) (Kumar et al, 2011).

Sample calculation 2.4 -

$$\textbf{\% sodium in sample} = \frac{ICPMS\ Reading}{Sample\ Weight} \times 100$$

2.6.6 Carbohydrate Determination

Total carbohydrate content was calculated by difference (Granfeldt *et al,* 2006). The other constituents in the food sample (protein, fat, and ash) were determined individually by analysis in g per 100g dry weight, and then subtracted from a 100 to determine carbohydrate content.

Sample calculation 2.5 -

CHO in 100g food sample = Dry Weight (100g) - (wt of [protein + fat + water + ash] (g))

2.7 Nutrient Database Analysis of School Meals 2002 & 2012

A comparison of the nutritional composition of the current 2012 school meals menu (Figure 2.1), and the historic 2002 menu (Figure 2.4), was determined from LCCG, menus. LCCG supplied all details including school menus and CRISp nutrient analysis for 2012 (info@crispsystems.com). For the analysis of 2002 LCCG school meals, an historic three week rolling menu was retrieved from LCCG archives (Eakhurst, R, Ass, Dir, LCC).

WEEK 1					
MENU 1	GOLDEN TURKEY DRUMMER	FISH & TOM SAUCE SEA SHELL	COOKS CHOICE PIZZA SLICE (V)	FISH FINGERS & TOMATO SAUCE	CHEESE & EGG FLAN
	CHEESE IN THE MOON	SOUP SANDWICHES	PORK TENDERLOIN & GRAVY	SPAGHETTI BOLOGNAISE	SAUSAGE & ONION GRAVY
MENU 2		CRISPS		OR LASAGNE	
ETHNIC	LENTIL DHAL & PITTA BREAD (V)	CHEESE & VEG VOL AU VENTS (V)	PANCAKE ROLL (V)	BOBBY ROLLS	HALAL SAUSAGE&ONION GRAVY
DAILY	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO
	CHIPS	CHIPS	SAUTE POTATOES	JACKET WEDGES	POTATO SMILES
CARBOHY	SAVOURY RICE	CREAMED POTATOES		1/2 GARLIC BREAD	
	COLESLAW	BROCCOLI FLORETS	CARROT & SWEETCORN	GARDEN PEAS	BAKED BEANS
VEG	ICED SPONGE TRIANGLE	CHOC MANDARIN GATEAUX	COOKIE & THICK MILKSHAKE	CORNFLAKE TART & CUSTARD	APPLE CRUMBLE & CUSTARD
	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES
DESSERTS	AND BISCUITS	AND BISCUITS	AND BISCUITS	AND BISCUITS	AND BISCUITS
	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS
	FROZEN YOGHURT	ICED CREAM TUB	FROZEN YOGHURT	ICED CREAM TUB	FROZEN YOGHURT
	ORANGE JUICE	ORANGE JUICE	LEMON JUICE	ORANGE JUICE	BLACKCURRANT JUICE
	FRESH MILK	FRESH MILK	FRESH MILK	FRESH MILK	STRAWBERRY MILK SHAKE

WEEK 2	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
MENU 1	BURGER IN BAP ONIONS TOM SCE	FISH SUNSHINE & TOM SCE	CHEESE & ONION WHIRLS (V)	ROAST CHICKEN & GRAVY	COOKS CHOICE PIZZA SLICE (V)
MENU 2	STELLA STARS or TOBYS TRIANGLE	MEAT & POTATO PIE F.M.	TURKEY TWIZZLERS	BAKED FISH BURGER	SAUSAGE ROLL
	OR BOBBY ROLLS (V)	or MINCE & YORKIES F.M.			
ETHNIC	CHEDDAR CHEESE PUFFS (V)	HALAL SAUSAGE	LAMB SAMOSA	VEGETABLE CRUNCH (V)	VEGETABLE ROLL (V)
DAILY	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO
CARBOHY	CHIPS	SAUTE POTATOES	NOISETTE POTATOES	CREAMED POTATOES	CHIPS
	PASTA SLAW			ROAST POTATOES	PASTA HOOPS
VEG	VEGETABLE STICKS	MUSHY PEAS	BAKED BEANS	CAULI & BROCCOLI FLORETS	PEAS & SWEETCORN
		SLICED BEETROOT			
					CHILDRENS FAVOURITE
DESSERTS	BUTTERFLY CAKES	CREAMED RICE PUDDING & JAM	ARTIC ROLL & FRUIT WEDGES	APPLE OAT SLICE	COOKIE & THICK MILK SHAKE
	AVAILABLE DAILY: CHOICE OF	**AVAILABLE DAILY: CHOICE OF**	**AVAILABLE DAILY: CHOICE OF**	**AVAILABLE DAILY: CHOICE OF**	**AVAILABLE DAILY: CHOICE OF**
	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES
	AND BISCUITS	AND BISCUITS	AND BISCUITS	AND BISCUITS	AND BISCUITS
	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS
	ICE CREAM TUB	FROZEN YOGHURT	ICE CREAM TUB	FROZEN YOGHURT	ICE CREAM TUB
DRINKS	ORANGE JUICE	BLACKCURRANT JUICE	ORANGE JUICE	BLACKCURRANT JUICE	LEMON JUICE
	FRESH MILK	BANANA MILK SHAKE	FRESH MILK	FRESH MILK	STRAWBERRY MILK SHAKE
MEAL 1	BURGER IN BAP ONIONS TOM SCE	FISH SUNSHINE & TOM SCE	TURKEY TWIZZLERS	ROAST CHICKEN & GRAVY	COOKS CHOICE PIZZA SLICE (V)
	CHIPS	SAUTE POTATOES	NOISETTE POTATOES	ROAST /CREAMED POTATOES	CHIPS
	VEGETABLE STICKS	MUSHY PEAS	BAKED BEANS	CAULI & BROCCOLI FLORETS	PEAS & SWEETCORN
MEAL 2	CHEDDAR CHEESE PUFFS (V)	MEAT & POTATO PIE F.M.	CHEESE & ONION WHIRLS (V)	BAKED FISH BURGER	SAUSAGE ROLL
	CHIPS	SLICED BEETROOT	NOISETTE POTATOES	CREAMED POTATOES	CHIPS
	VEGETABLE STICKS		BAKED BEANS	CAULI & BROCCOLI FLORETS	PEAS & SWEETCORN
MEAL 3	STELLA STARS or TOBYS TRIANGLE	HALAL SAUSAGE	LAMB SAMOSA	VEGETABLE CRUNCH (V)	VEGETABLE ROLL (V)
	OR BOBBY ROLLS (V)	SAUTE POTATOES	NOISETTE POTATOES	ROAST /CREAMED POTATOES	CHIPS
	PASTA SLAW	MUSHY PEAS	BAKED BEANS	CAULI & BROCCOLI FLORETS	PEAS & SWEETCORN
	VEGETABLE STICKS				

WEEK 3	**MONDAY**	**TUESDAY**	**WEDNESDAY**	**THURSDAY**	**FRIDAY**
MENU 1	BUTTER PIE (V) or	MEATBALLS IN PASTA HOOPS	HOT DOG IN FINGER ROLL	COOKS CHOICE PIZZA SLICE (V)	GOLDEN FISH WHALES
	CHEESE & POTATO FLAN	1/2 Portion GARLIC BREAD	ONIONS & TOMATO SAUCE		
MENU 2	CHICKEN SPELLBINDERS	FISH FINGERS IN TOM SAUCE	CRUNCHIE COD BITES	ROAST PORK & GRAVY	MEAT PIE & GRAVY
					or MINCE & DUMPLING
ETHNIC	HALAL BURGER IN GRAVY	MEAT SAMOSA	HALAL CHICKEN SAUSAGE	BEAN & VEGETABLE CASSEROLE	CHEESE & ONION DISCO (V)
			FINGER ROLL ONIONS TOM SCE	(V)	
DAILY	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO	FILLED JACKET POTATO
CARBO	POTATO SMILES	CREAMED POTATOES	CHIPS OR PASTA SLAW	NOISETTE POTATOES	CHIPS
				ROAST POTATOES	CREAMED POTATOES
VEG	GLAZED CARROTS	BROCCOLI FLORETS	BAKED BEANS	PUREE OF CARROT & SWEDE	PEAS & SWEETCORN
DESSERTS	CHILDRENS FAVOURITE	FLAP JACK	RASPBERRY & APPLE ROLY	JELLY & ICE CREAM	PEARS IN SAUCE
	COOKIE & THICK MILK SHAKE		POLY & SAUCE		
	AVAILABLE DAILY: CHOICE OF	**AVAILABLE DAILY: CHOICE OF**	**AVAILABLE DAILY: CHOICE OF**	**AVAILABLE DAILY: CHOICE OF**	**AVAILABLE DAILY: CHOICE OF**
	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES	SELECTION OF HOMEMADE CAKES
	AND BISCUITS	AND BISCUITS	AND BISCUITS	AND BISCUITS	AND BISCUITS
	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS	FRESH FRUIT BOWLS
	FROZEN YOGHURT	ICE CREAM TUB	FROZEN YOGHURT	ICE CREAM TUB	FROZEN YOGHURT
DRINKS	ORANGE JUICE	BLACKCURRANT JUICE	ORANGE JUICE	BLACKCURRANT JUICE	LEMON JUICE
	FRESH MILK	BANANA MILK SHAKE	FRESH MILK	FRESH MILK	STRAWBERRY MILK SHAKE
	MEAL OPTIONS	**MEAL OPTIONS**	**MEAL OPTIONS**	**MEAL OPTIONS**	**MEAL OPTIONS**
MEAL 1	BUTTER PIE (V)	FISH FINGERS IN TOM SAUCE	HOT DOG IN FINGER ROLL	COOKS CHOICE PIZZA SLICE (V)	GOLDEN FISH WHALES
	GLAZED CARROTS	CREAMED POTATOES	CHIPS OR PASTA SLAW	NOISETTE POTATOES	CHIPS or CREAMED POTATO
		BROCCOLI FLORETS	BAKED BEANS	PUREE OF CARROT & SWEDE	PEAS & SWEETCORN
MEAL 2	CHICKEN SPELLBINDERS	MEATBALLS IN PASTA HOOPS	CRUNCHIE COD BITES	ROAST PORK & GRAVY	MEAT PIE & GRAVY
	POTATO SMILES	1/2 GARLIC BREAD	CHIPS OR PASTA SLAW	ROAST POTATOES	CHIPS or CREAMED POTATO
	GLAZED CARROTS	BROCCOLI FLORETS	BAKED BEANS	PUREE OF CARROT & SWEDE	PEAS & SWEETCORN
MEAL 3	HALAL BURGER IN GRAVY	MEAT SAMOSA	HALAL CHICKEN SAUSAGE	BEAN & VEGETABLE CASSEROLE	CHEESE & ONION DISCO (V)
	POTATO SMILES	CREAMED POTATOES	FINGER ROLL ONIONS TOM SCE	ROAST POTATOES	CHIPS or CREAMED POTATO
	GLAZED CARROTS	BROCCOLI FLORETS	CHIPS OR PASTA SLAW	PUREE OF CARROT & SWEDE	PEAS & SWEETCORN
			BAKED BEANS		

2.8 Nutrient Database Analysis

Both 2012 and 2002 three week rolling menus were imputed into a nutrient database analysis computer package (WinDiets, 2008 The Robert Gordon University, Aberdeen, UK). WinDiet nutrient database (WND) allows a daily analysis of up to six meals, however for the purposes of this analysis we imputed the three daily meals which were included on the menu, and repeated this for three weeks. A daily nutrient total was derived for the three meals, and this was then divided by three to achieve a daily nutrient average meal. A full nutrient analysis was undertaken for both 2012 and 2002 rolling menus (Figure 2.1 & 2.4). The LCCG school meal samples had been collected for laboratory analysis, and their total meal weight had been recorded as described in Figure 2.2. These recorded total meal weights were used in combination with portion size guidelines provided by WND to estimate the weights of the individual meal components such as potatoes, fish and vegetables etcetera, for the 2012 LCCG school menu. As it was not possible to establish a portion size for the 2002 historic LCCG school menu (Figure 2.4), the 2012 school meal collection weights were used as a guide for 2002 menu also. Where possible each menu item was matched as closely as possible to the foods listed in the WND. For example where the menu states 'Jacket Potato with choice of filling', throughout the three week meal collection every Jacket potato collected was filled with cheddar cheese, so both 2002 and 2012 were based on this filling. Furthermore, where the description of food type was not available in WND, for example Bobby rolls, Potato smiles, Cheese in the moon, Turkey twizzler, Stella Stars and Toby Triangles, these food descriptions were investigated as thoroughly as possible. For example, teachers were questioned to see if they could remember a description of these foods, and also an internet search was undertaken to find any possible matches. The description of each food was were possible matched in the WND menu, however if it was not available it was represented by a similar food, for example

Turkey twizzler was represented by 'Turkey steak in crumbs', and Potato smiles were represented by potato croquettes, and the portion size was adapted.

2.9 Nutrients considered

WND analysis produces a list of 40 nutrients plus energy (kcal), however when undertaking laboratory analysis each nutrient is analysed individually. As this study is evaluating the comparable findings between WND analysis and Laboratory analysis it is necessary to keep this analysis to manageable proportions as time limitations need to be taken into consideration. Therefore for this study we selected energy (kcal), macro-nutrients, protein, carbohydrates, and total fat, to assess key macronutrients in the diet and compare to GNBS. Furthermore at this time, it would not be possible to undertake a more detailed lipid composition analysis as the laboratory facilities needed are not available likewise with non milk extrinsic sugars (NMES).

Following our literary review we chose micronutrients which have been extensively researched with regard to child nutrition and brain development. Therefore the micronutrients analysed were calcium, which is extremely important in childhood for the development of peak bone mass. Secondly, iron was analysed because learning and cognition is negatively influenced by iron deficiency. Thirdly sodium was analysed because it was the key micronutrient GNBS restrictions for school meals.

2.10 Statistical Analysis

2.10.1 A Comparison between, Laboratory values, WND values, and GNBS for the nutrient content of LCCG school meals

Data were analysed using the statistical analysis package SPSS Version 20.0 for windows (IBM SPSS 2012). Data were assessed for normality using the Kolmogorov-Smirnov test and the Shapiro-Wilk test, results were non-significant suggesting normality. Statistical significance level was set at $p < 0.05$. The mean, standard deviation, were determined for all variables were used to evaluate differences between Laboratory analyses, WND analysis 2012, and GNBS, 2007. The statistical analysis selected was a One-sample t-test to compare Laboratory values with GNBS, and to compare WND values with GNBS. An independent-samples t-test was used to compare the differences between values for both laboratory analyses, and WND analysis 2012.

2.10.2 A Comparison between WND values of School Meal menus 2002 & 2012

Data were analysed using the statistical analysis package SPSS Version 20.0 for windows (IBM SPSS 2012). Data were assessed for normality using the Kolmogorov-Smirnov test and the Shapiro-Wilk test, results were non-significant suggesting normality. Statistical significance level was set at $p < 0.05$. The mean, standard deviation, were determined for all variables and were used to evaluate the differences between the school meal menus 2002 and 2012. An independent-samples t-test was used to identify any significant differences between the values derived from WinDiet menu analysis 2002, and 2012. A One-sample t-test was used to compare the WND menu analysis 2002 with GNBS, and the WND menu analysis 2012 with GNBS.

2.11 Cognitive Study

2.11.1 The Impact of a Mid-Morning Snack on Cognitive Performance

The same Lancashire primary school which had been selected as a representative for the school meal analyses was also used to investigate the impact of snacks on cognitive performance. Daily provision consisted of a mid-morning fruit snack, provided by the school fruit and vegetable scheme (SFVS, 2007), but only for infants (reception –year2).

2.11.2 Recruitment for cognitive testing

Year 2 pupils (aged 6-7) were invited to participate in a short term memory test. The exclusion criteria included ill health and learning disorders, all selected participants fulfilled the criteria. Consent was obtained from the head teacher of the school selected (As shown in appendix). Parents of 35 year 2 pupils were provided with consent forms which had to be signed and returned (As shown in appendix). Parents were also provided with information sheet on the study, to cover any possible questions they might have. A total of 24 pupils returned signed consent forms and 11 pupils did not, this was recorded as a decline. A total of 21 pupils (10 girls and 11 boys) completed testing as (2 girls and 1 boy) missed testing due to ill health.

2.11.3 Test Method for Cognitive Performance

Short term memory was tested using an age modified version of Kim's Game, a Visual memory test (www.educationscotland.gov.uk/studyskills/kimsgame/index.asp). Test 1, 21 pupils were tested in school, pre mid-morning break time without a fruit snack. In a quiet classroom area, pupils were seated equally, a suitable distance away from each other. On the table in front of each pupil, a test sheet displaying 20 pictures on was placed face down (Figure 2.5). 10 pictures from the test sheet were reprinted and stuck to a board (Figure 2.6), which was covered with a sheet. Pupils were instructed that the board would be uncovered and that they would have one minute to look and remember as many pictures as possible. After one minute the board was re-covered, and pupils could then turn over their sheet and draw a circle around the pictures they could recall.

Figure 2.5 Cognitive Test (Answer Sheet)

Figure 2.6 Cognitive Tests (Picture Board)

Test 2, procedure was repeated on the same weekday, one week later, in the same classroom before mid-morning break time. Pupils were given their mid-morning fruit snack, 10-15 minutes before testing commenced. Pupils were seated as they were in test 1. On second testing, the pictures from test 1 were re-arranged to avoid any testing effect and threat to internal validity (Trochim *et al*, 2006).

2.11.4 Scoring Method

Children were assessed with a three tier scoring method; firstly 1 mark was given for a circling of a picture identified correctly. Secondly 1 mark was removed for an incorrect circling of a picture. Thirdly a half mark was removed for no answer, as this was neither correct nor incorrect.

2.11.5 Data Analysis

Data was analysed using the statistical analysis package SPSS Version 20.0 for windows (IBM SPSS 2012). The mean, standard deviation, were determined for all variables. Cognitive performance data were assessed for normality using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. As results were significant suggesting a violation of the assumption of normality, a non-parametric test Wilcoxen signed rank test was used to assess differences between test1 and test 2. Statistical significance level was set at $p < 0.05$.

CHAPTER 3

AN ANALYSIS OF PRIMARY SCHOOL MEALS COMPARED TO GOVERNMENT NUTRIENT BASED STANDARDS

RESULTS

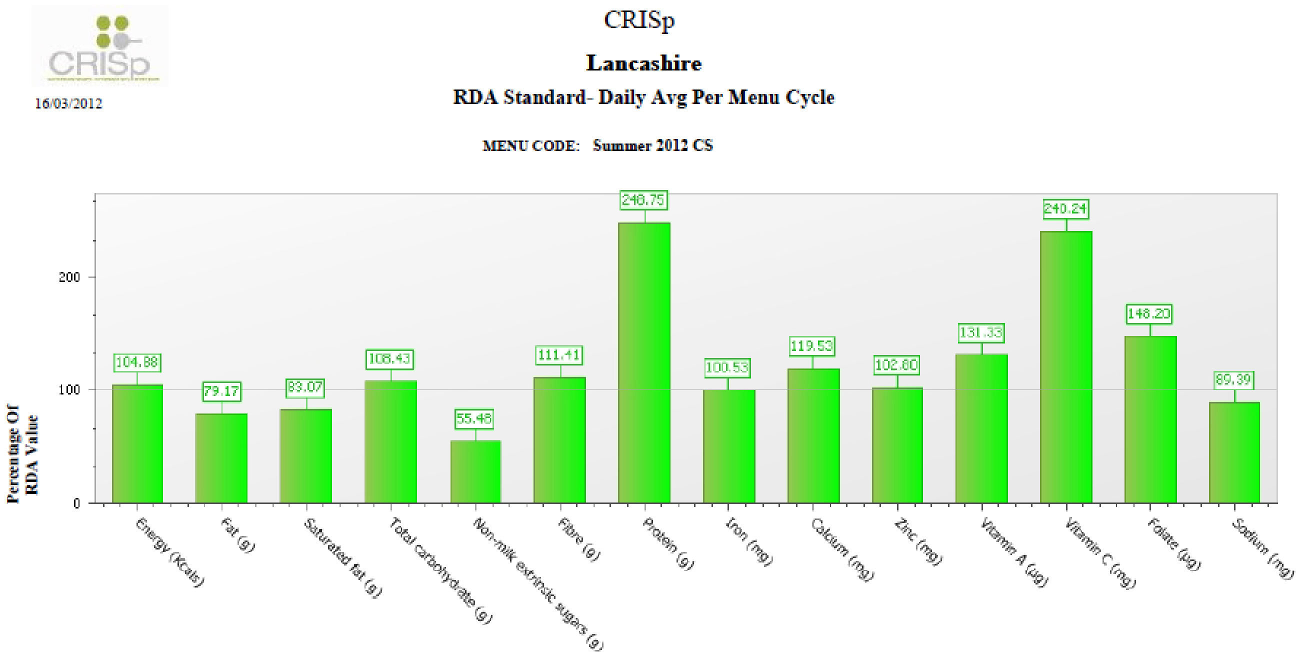
3.1 Overview of this chapter

In this chapter the results which are reported are in line with aim 1, which was to undertake an analysis of the school meals provided by LCCG, to primary schools in Lancashire, and to compare these findings to GNBS, 2007. There are two main sections; section 1, presents the findings which were produced by laboratory and WND analysis of each daily average school meal for fifteen days, and the mean ± SD, of each macro and micronutrient is reported plus energy kcal. The nutritional findings are compared to GNBS and the statistical significance is reported. In section 2, macronutrients are reported as % of energy, and micronutrients are reported as mg/kcal. Finally this chapter will finish by summarising the findings in this chapter.

3.2 A Comparison of LCCGSchool meal Analysis and GNBS

LCC Group, work with nutritionists and use the industry recognised computer software system CRISp (info@crispsystems.com) an analysis of the school meals supplied to Lancashire primary schools is shown in figure 3.1. The CRISp analysis of the LCCG schools meals which are provided to Lancashire primary schools shows that they meet GNBS. In order to test this independently an alternative nutrient database (Windiets) was used, and in addition laboratory analyses were performed.

Figure 3.1 - LCCG CRISp Analysis

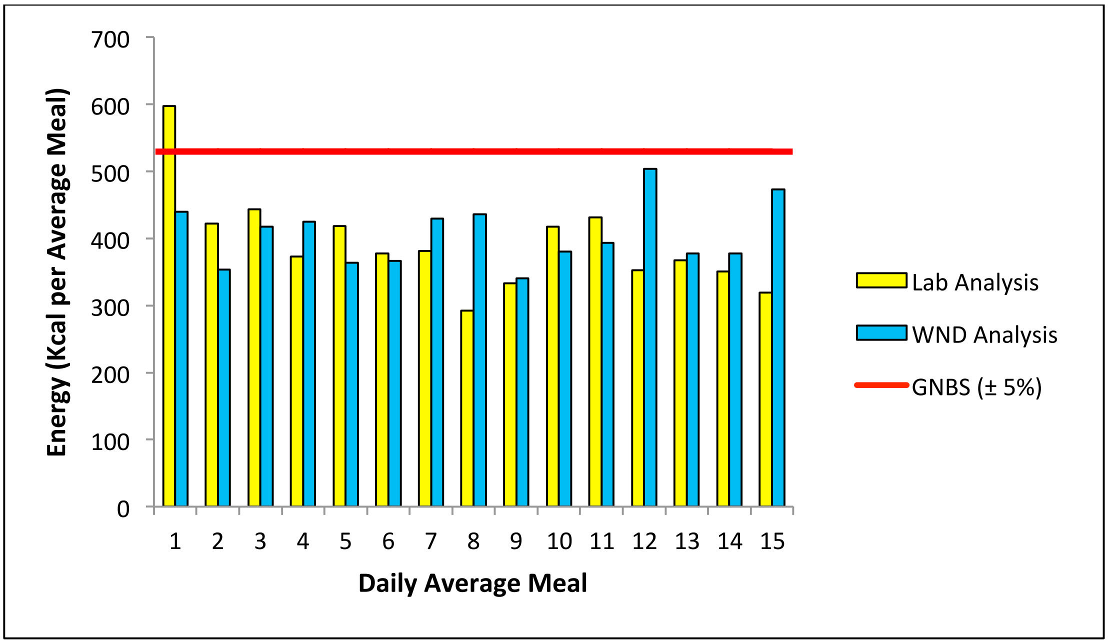


3.3 Nutrient differences per daily average meal: Laboratory and Nutrient database analysis of LCCG school meals, Compared with GNBS.

In this section, the results of the WND analysis and laboratory analysis of the average LCCG daily average school meal, are presented and compared to GNBS.

3.3.1 Energy Content

Using Bomb Calorimetry, the total energy content in kcal per daily average school meal, was determined to be 392±72 kcal / meal, (mean ±SD). Using an indirect food composition database, WND analysis, the mean energy content per meal was 411 ± 44 kcal / meal, (mean ± SD). One-sample t-tests were conducted to compare the differences between the mean energy values kcal per meal, derived from laboratory analysis with GNBS, and WND analysis with GNBS. Results revealed that a significant difference was detected between laboratory analysis and GNBS (p<0.001 (two-tailed), t (14) = -7.49, (mean difference = -139, 95% CI: -178 to -99). A significant difference was also detected between WND analysis and GNBS (p<0.001 (two-tailed), t (14) = -10.43, (mean difference = -119, 95% CI: -144 to -95). Therefore, both values derived from the laboratory and WND analysis fell significantly below the GNBS 530 kcal, ± 5% per meal. C_v= Standard Deviation / Mean = 0.01

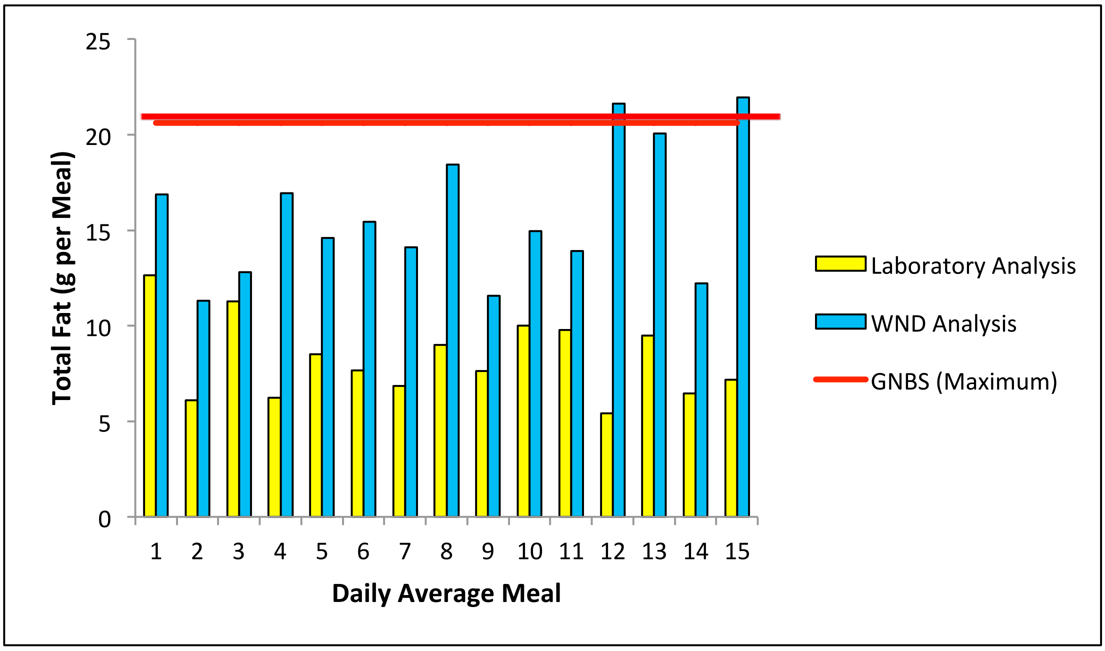


Significance Level set at P < 0.05

Figure 3.2 - Bar chart showing total energy kcal per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.3.2 Total Fat Content

Using Soxtec, the total fat content in (g) per daily average school meal, was determined to be 8.28 ± 2.1g / meal (mean ±SD). Using WND analysis, the mean total fat content was 15.78 ± 3.5 g / meal (mean ± SD). One-sample t-tests were conducted to compare the differences between the mean total fat value per meal, derived from laboratory analysis with GNBS, and WND analysis with GNBS. Results revealed that a significant difference was detected between laboratory analysis and GNBS ($p<0.001$ (two-tailed), t (14) = -23.08, (mean difference = -12.32, 95% CI: -13.46 to -11.18). A significant difference was also detected between WND analysis and GNBS ($p<0.001$ (two-tailed), t (14) = -5.38, (mean difference = -4.82, 95% CI: -6.74 to -2.90). Therefore, both values derived from the laboratory and WND analysis fell significantly below the maximum GNBS 20.6g. C_v= Standard Deviation / Mean = 0.02



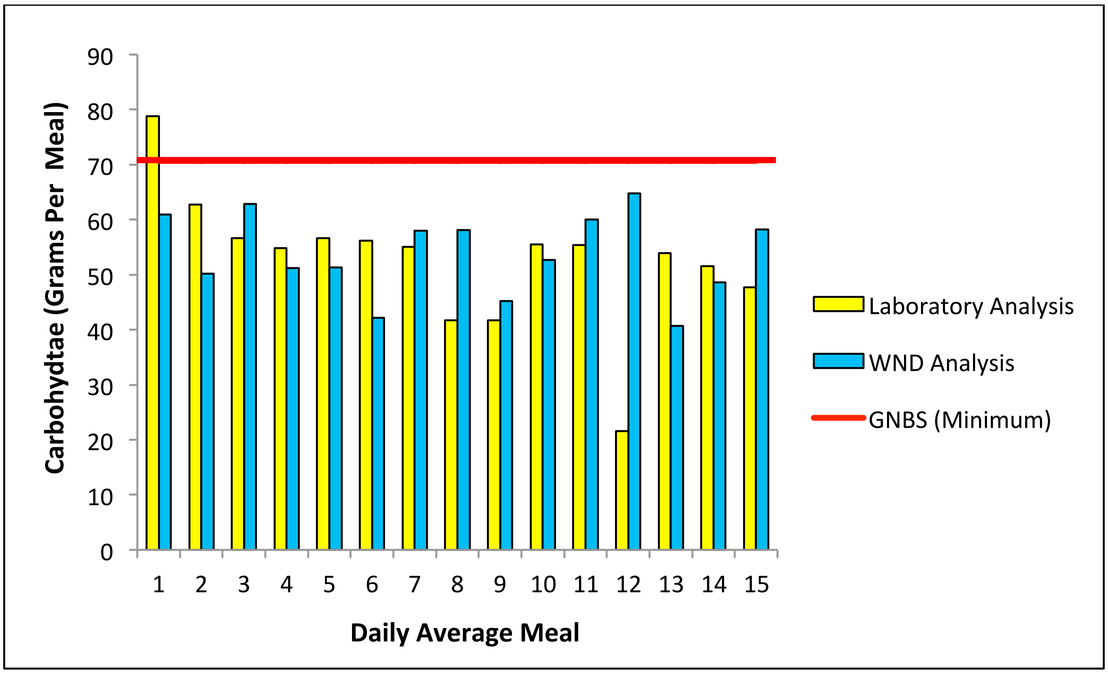
Significance Level set at $P < 0.05$

Figure 3.3 - Bar chart showing total fat content (g) per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.3.3 Carbohydrate Content

Calculating by difference, the total carbohydrate content in (g) per daily average school meal, was determined to be 52.66 ± 12.22 g / meal (mean ± SD). Using WND analysis, the mean carbohydrate content per meal was 53.67 ± 7.49g / meal (mean ±SD). One-sample t-tests were conducted to compare the differences between the mean carbohydrate values per meal, derived from laboratory analysis with GNBS, and WND analysis with GNBS. Results revealed that a significant difference was detected between laboratory analysis and GNBS (p<0.002 (two-tailed), t (14) = -5.69, (mean difference = -17.94, 95% CI: -24.71 to -11.18). A significant difference was also detected between WND analysis and GNBS (p<0.001 (two-tailed), t (14) = -8.76, (mean difference = -16.93, 95% CI: -21.07 to -12.78). Therefore, both values derived from the laboratory and WND analysis fell significantly below the minimum GNBS 70.60 g.

C_v= Standard Deviation / Mean = 0.23

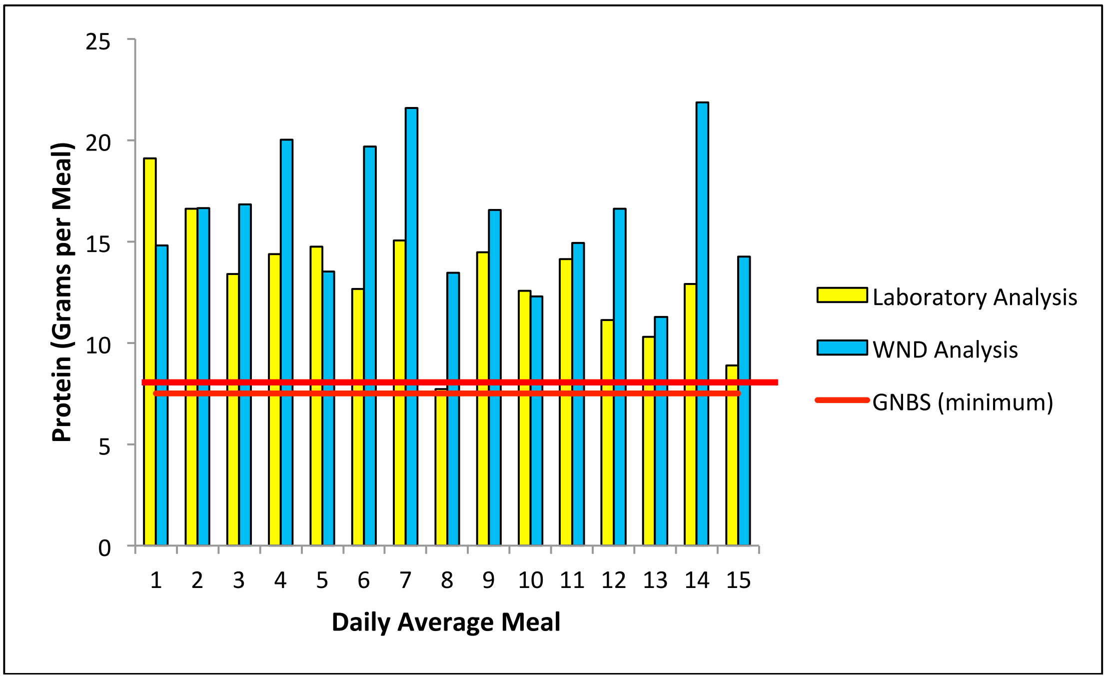


Significance Level set at $P < 0.05$

Figure 3.4 - Bar chart showing carbohydrate content (g) per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.3.4 Protein Content

Using Kjeldahl**,** the total protein content in (g) per daily average school meal, was determined to be 13.21 ± 2.9 g / meal (mean ± SD). Using WND analysis, the mean protein content per meal was 16.30 ± 3.27g / meal (mean ±SD). One-sample t-tests were conducted to compare the differences between mean protein content values per meal, derived from laboratory analysis and GNBS, and WND analysis with GNBS. Results revealed that a significant difference was detected between laboratory analysis and GNBS ($p<0.001$ (two-tailed), $t\,(14) = 7.60$, (mean difference = 5.71, 95% CI: 4.10 to 7.32). A significant difference was also detected between WND analysis and GNBS ($p<0.001$ (two-tailed), $t\,(14) = 10.41$, (mean difference = 8.80, 95% CI: 6.99 to 10.61). Therefore, both values derived from the laboratory and WND analysis were significantly higher than the minimum GNBS 7.5g. C_v= Standard Deviation / Mean = 0.22

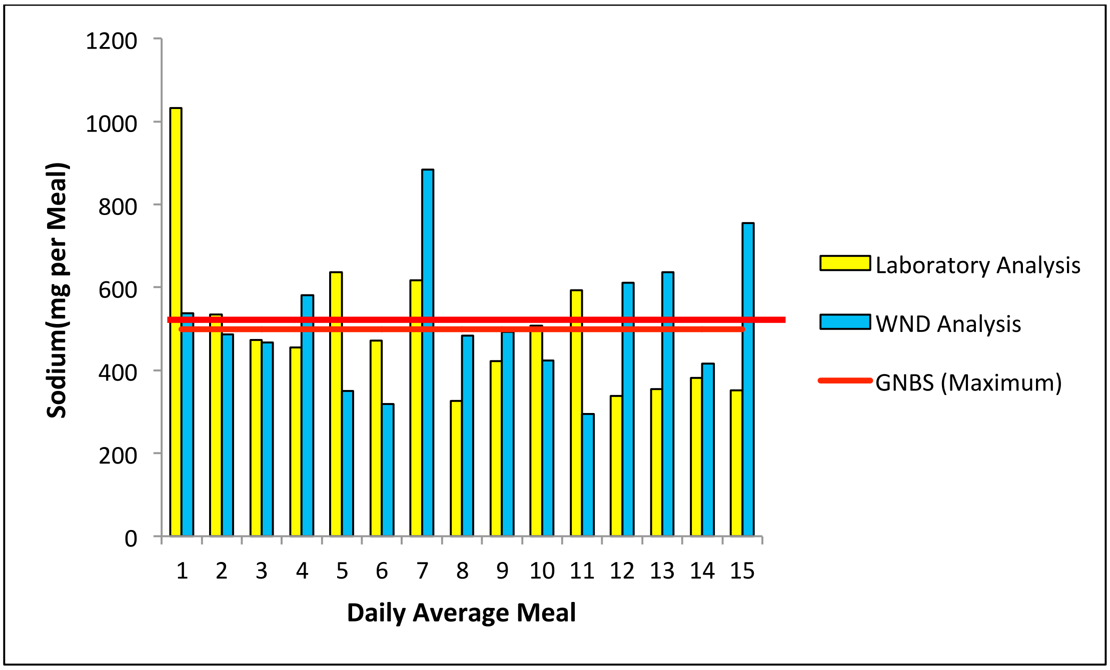


Significance Level set at $P < 0.05$

Figure 3.5 - Bar chart showing Protein content (g) per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.3.5 Sodium Content

Using (ICP-MS), the total sodium content in (mg) per daily average school meal, was determined to be 500 ± 179 mg / meal (mean ±SD). Using WND analysis, the mean sodium content per meal was 516 ± 160mg / meal (mean ± SD). One-sample t-tests were conducted to compare the differences between the mean sodium content values per meal, derived from laboratory analysis and GNBS, and WND analysis with GNBS. Results revealed that there was no significant difference detected between laboratory analysis and GNBS (p<0.987 (two-tailed), t (14) = 0.017, (mean difference = 0.767, 95% CI: -98.33 to 99.86). There was also no significant difference detected between WND analysis and GNBS (p<0.690 (two-tailed), t (14) = 0.407, (mean difference = 16.85, 95% CI: -71.86 to 105.55). Therefore, both values derived from the laboratory and WND analysis were significantly higher than the maximum GNBS 499 mg. C_v= Standard Deviation / Mean = 0.36

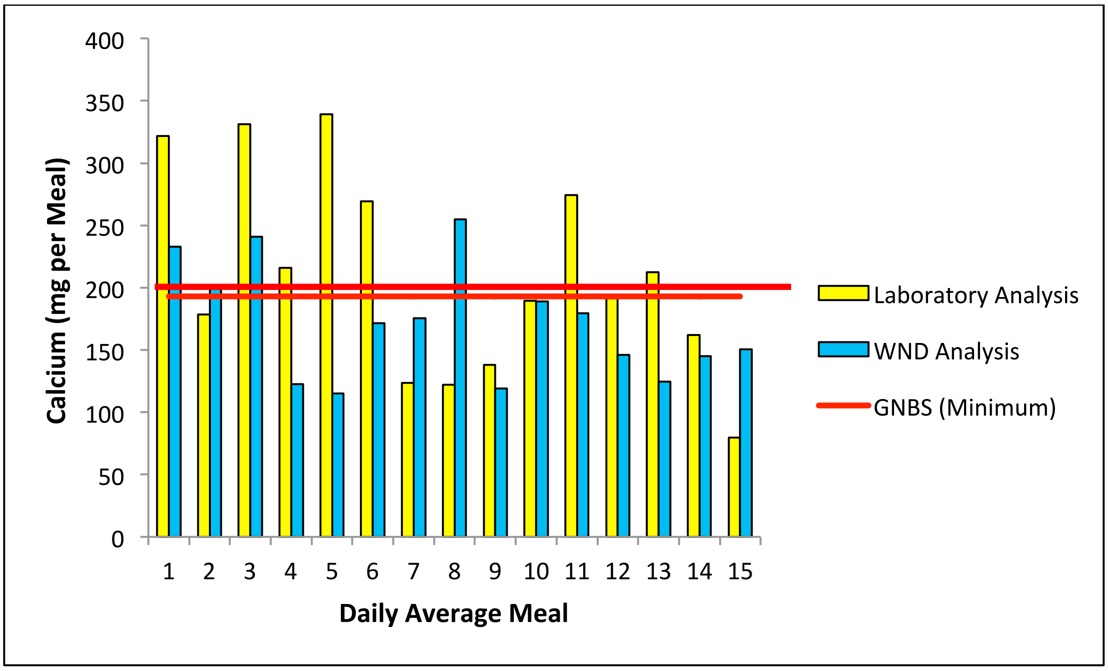


Significance Level set at P < 0.05

Figure 3.6 - Bar chart showing sodium content (mg) per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.3.6 Calcium Content

Using (ICP-MS), the total calcium content in (mg) per average daily school meal, was determined to be 210 ± 81mg / meal (mean ± SD). Using WND analysis, the mean calcium content per meal was 171 ± 46 mg / meal (mean ± SD). One-sample t-tests were conducted to compare the differences between the mean calcium content values per meal, derived from laboratory analysis and GNBS, and WND analysis with GNBS. There was no significant difference detected between laboratory analysis and GNBS ($p<0.434$ (two-tailed), t (14) = .805, (mean difference = 16.93, 95% CI: - 28.19 to 62.05). There was also no significant difference detected between WND analysis and GNBS ($p<0.087$(two-tailed), t (14) = -1.84, (mean difference = -21.73, 95% CI: -47.03 to 3.57). Though the mean values derived from the laboratory and WND analysis were not significantly different than the minimum GNBS 193 mg, the values derived from the laboratory analysis failed to meet the minimum GNBS. C_v= Standard Deviation / Mean = 0.39

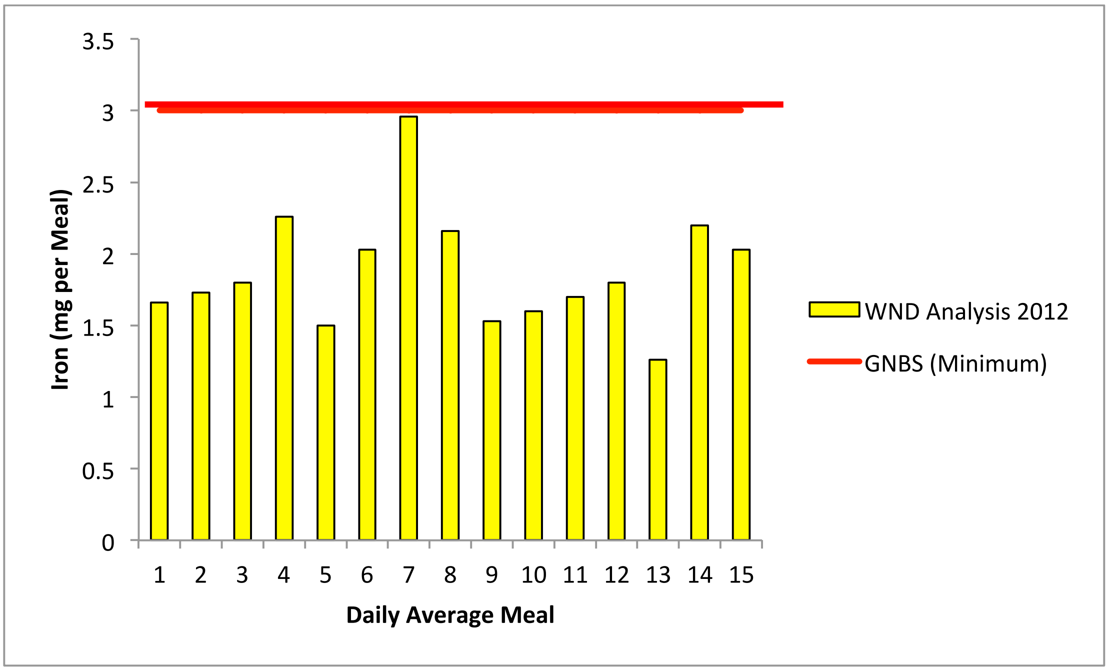


Significance Level set at $P < 0.05$

Figure 3.7 - Bar chart showing calcium content (mg) per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.3.7 Iron Content

Iron values per average daily school meal were determined using (ICP-MS), however due to probable contamination the findings could not be reported. Therefore our findings will be reported in part and only in this section. Using WND analysis, the mean iron content per meal was 1.87 ± .40 mg / meal (mean ± SD). A one-sample t-test was conducted to compare the difference between the mean iron content values per meal, derived from WND analysis with GNBS. Results revealed that a significant difference was detected between WND analysis and GNBS (p<0.001 (two-tailed), t (14) = -11.03, (mean difference = - 1.13, 95% CI: -1.35 to 0.91). Therefore the mean values derived from the WND analysis fell significantly below the minimum GNBS 3.0 mg. C_v= Standard Deviation / Mean = 0.21



Significance Level set at $P < 0.05$

Figure 3.8 - Bar chart showing iron content (mg) per daily average school meal, WND analysis compared with GNBS.

3.4 School Meal Composition

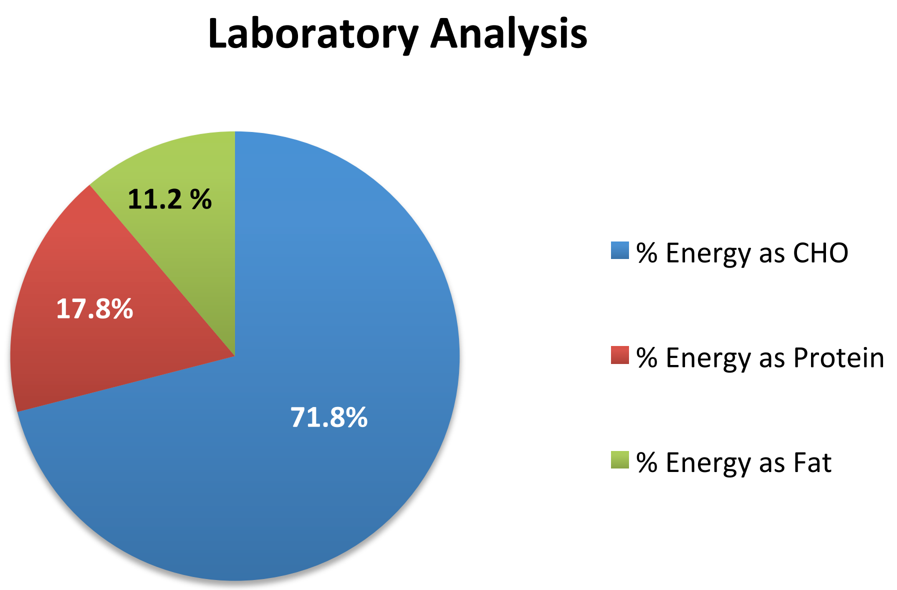
Both the laboratory and WND analysis revealed that the energy content of the school meals fell significantly below the minimum recommended GNBS of (530 kcal per meal, $\pm$ 5%). To provide a method of comparing nutritional quality per average school meal, mean content per meal for macronutrients are reported as a % of the energy content kcal. To compare the differences between values derived for calcium and sodium, the mean content was calculated as nutrient density per kcal for laboratory analyses and WND analysis and GNBS.

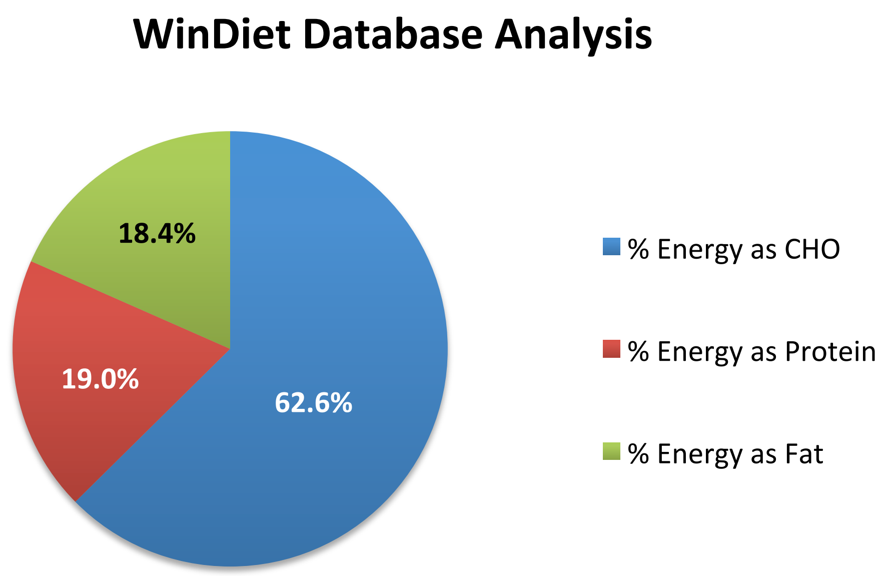
3.4.1 Macronutrients as a % of Energy

The FSA advise that the school meal should aim to provide about 30% of daily total energy intake, breakfast and evening about 50% and snacks about 20%. The GNBS for total energy for the school meal advise this to be about 530 Kcal, $\pm$ 5% per school meal. The laboratory analysis reported a mean energy 392 kcal per meal; this would provide 74% of the recommended GNBS. WND analysis reported a mean energy 411 kcal per meal; which would provide77.5% of the recommended GNBS.

Dietary recommendations from the FSA suggest that a healthy balanced meal should consist of around 55-60% carbohydrate from energy, around 30-35% from fat, and around 10-15% from protein. The SFT, 2013 states that it is important that the school meal should contain sufficient energy and micronutrients, to promote good health for those who are nutritionally vulnerable. However it should be noted that the FSA % nutrient recommendations are designed for a whole daily intake. This means that it is not necessary that each meal meets these nutrient %'s specifically, as nutrient intake ideally should be balanced throughout the day.

Figure 3.9 - Macronutrients, CHO, Protein and Total fat are shown as a % of mean energy kcal

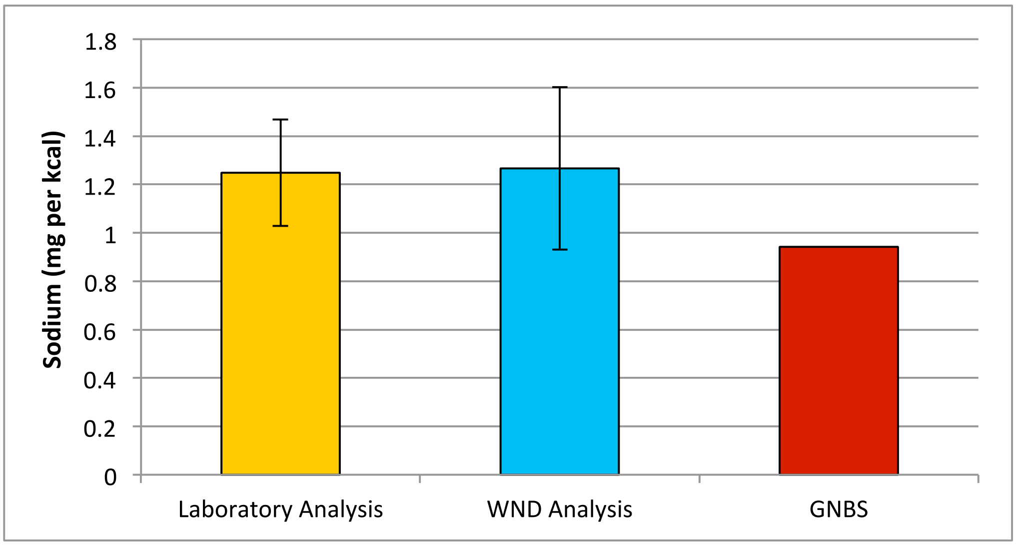




3.4.2 Sodium and Calcium Content mg/kcal

3.4.2.1 Sodium

The sodium content (mg) per average daily school meal, determined using ICP-MS and using WND analysis were converted into mg/kcal. These energy adjusted mean (± SD) values were 1.25 ± 0.22 mg/kcal, and 1.27 ± 0.34 mg/kcal for ICP-MS and WND analysis respectively. One-sample t-tests were conducted to compare the differences between the mean sodium content, mg/kcal, derived from ICP-MS analysis and GNBS, and WND analysis with GNBS. Results revealed that a significant difference was detected between laboratory analysis and GNBS (p<0.001 (two-tailed), t (14) = 5.40, (mean difference = 0.308, 95% CI: 0.186 to 0.431). A significant difference was also detected between WND analysis and GNBS (p<0.002 (two-tailed), t (14) = 3.76, (mean difference = 0.326, 95% CI: 0.140 to 0.513). Both converted values derived from the laboratory and WND database analysis were significantly higher than the maximum recommended GNBS 0.942 mg/Kcal.

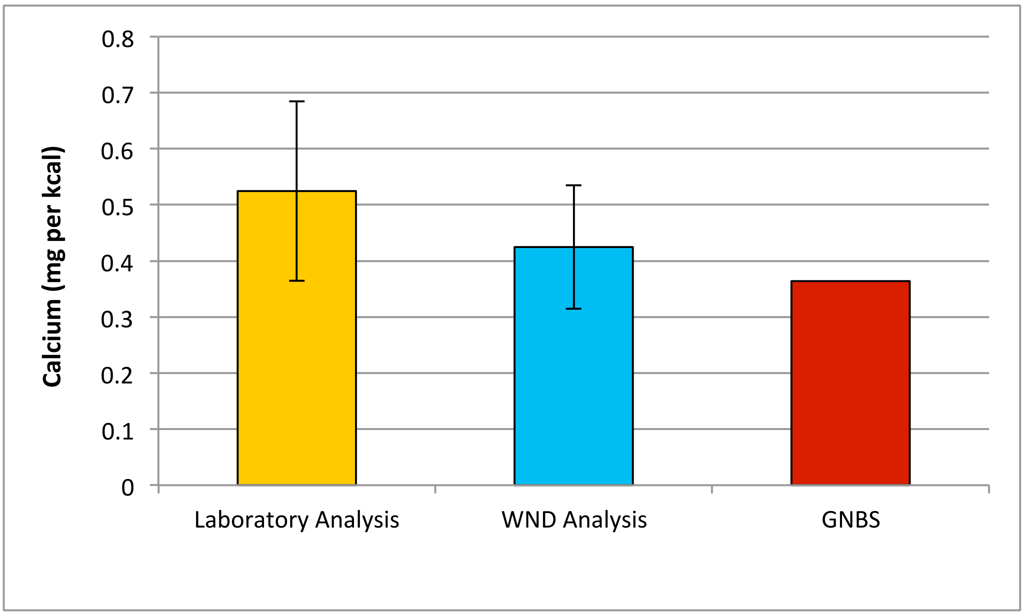


Significance Level set at $P < 0.05$

Figure 3.10 - Bar chart showing mean sodium content mg/kcal per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.4.2.2 Calcium

The calcium content for each average meal, determined using ICP-MS and WND analysis were converted into mg/kcal. These energy adjusted mean (± SD) values were 0.53 ± 0.16 mg/kcal and 0.42 ± 0.11 mg/kcal for ICP-MS and WND analysis respectively. One-sample t-tests were conducted to compare the differences between the mean calcium content, mg/kcal, derived from ICP-MS analysis and GNBS, and WND analysis with GNBS. There was no significant difference detected between laboratory analysis and GNBS ($p<0.434$ (two-tailed), t (14) = 4.13, (mean difference = 0.165, 95% CI: 0.079 to 0.250). There was also no significant difference detected between WND analysis and GNBS ($p<0.037$(two-tailed), t (14) = 2.30, (mean difference = 0.065, 95% CI: 0.004 to 0.125). Both converted values derived from the laboratory and WND analysis met the minimum recommended GNBS, 0.36 mg/Kcal.



Significance Level set at $P < 0.05$

Figure 3.11 - Bar chart showing mean calcium content mg/kcal per daily average school meal, Laboratory and WND analysis compared with GNBS.

3.5 Differences between values derived from Laboratory and WND analysis

There is no ideal tool for dietary analysis, any measurement of nutrients is problematic and subject to errors, plus research has shown that there can be statistical differences between analytical methods (Weber & Morais, 2010). For this reason we decided to use both WND analysis and Laboratory analysis as a comparison as they are different methods of measurement. Independent-samples t-tests were conducted to compare means for Laboratory analysis and WND analysis.

Table 3.1 - Differences between Laboratory and WND analysis, derived from Independent T Tests.

Nutrient	*P* <0.001 Two-tailed	t-value	Mean Diff	95% CI	Significance
Energy (kcal)	*P*< 0.329	(28) = 0.869	18.88	-25.64 to 63.40	Not sig
CHO (g)	*P*< 0.786	(28) = 0.274	1.01	-6.56 to 8.59	Not sig
Protein (g)	*P*< 0.011	(28) = 2.731	3.09	0.772 to 5.41	Significant
Total fat (g)	*P*< 0.001	(28) = 7.201	7.5	5.4 to 9.6	Significant
Sodium(mg)	*P*< 0.870	(28) = 0.165	10.56	-120.78 to 141.90	Not sig
Calcium(mg)	*P*< 0.123	(28) = -1.603	-38.66	-88.68 to 11.35	Not sig

3.6 Summary

In summary, both the laboratory and WND analysis revealed that the energy content of the LCCG school meals provided to primary aged children fell significantly below the minimum GNBS. The energy kcal provided was about 25% below the GNBS; these findings were also observed by the SFT, 2007. Macronutrients in part met GNBS; mean protein values met the minimum standard with a 50% increase on the recommended value of 7.5g. Total fat values did not exceed the maximum GNBS, revealing a mean total less than 50% of the maximum GNBS. However, mean carbohydrate failed to meet the minimum GNBS, these findings were also observed by the SFT, 2009. Both calcium and sodium analyses revealed mean values which were not significantly different than GNBS, however iron WND analyses revealed mean values which were significantly lower than the minimum GNBS 3mg. When macronutrients were reported as a % of the energy content in kcal, carbohydrates values were between 62.6 and 71.8%, protein values were between 17.8 and 19% and total fat values were between 11.2 and 18.4%. The recommended intake for a healthy balance meal would suggest that carbohydrates should provide about 55 -60% of energy, total fat about 30 -35% and protein about 10 -15% (BNF, 2013). When calcium and sodium, were calculated as mg/ kcal, values for calcium met GNBS. However sodium levels were significantly higher than the maximum recommended GNBS; these findings were also observed by the SFT, 2007. The laboratory based and WND analyses did produce significantly different results for some nutrients and not others. Results for energy, carbohydrate, calcium and sodium were not statistically significantly different; however results for total fat and protein were significantly different.

CHAPTER 4

NUTRIENT DATABASE ANALYSIS OF SCHOOL MEALS

2002 & 2012

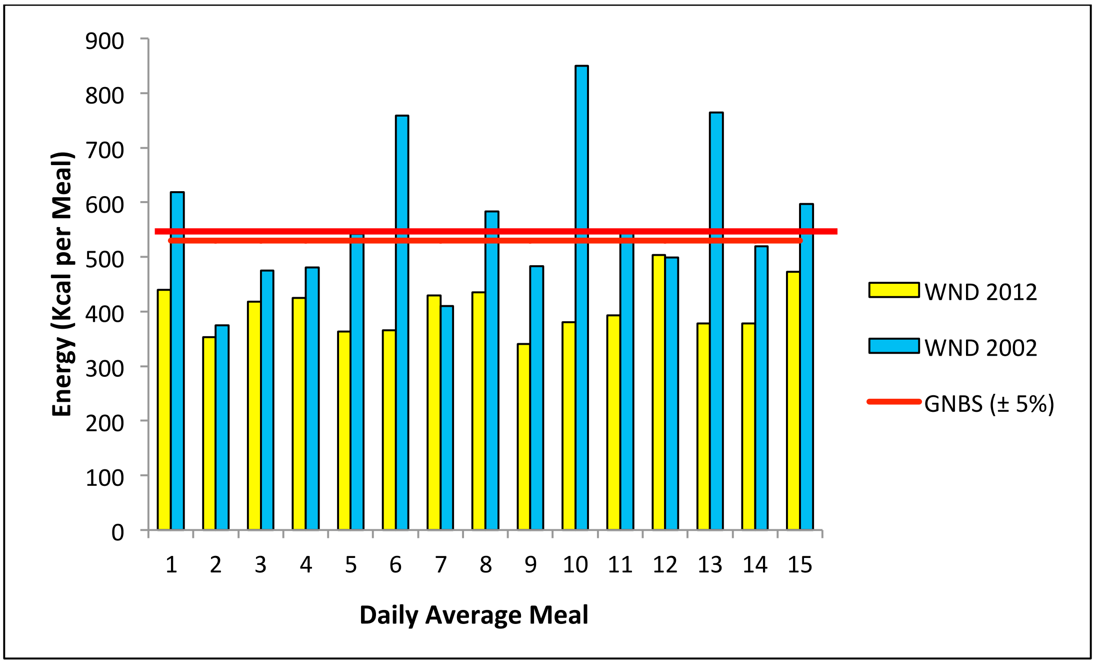
RESULTS

4.1 Overview of this chapter

In this chapter the results which are reported are in line with aim 2, an analysis and comparison of the current 2012 and historic 2002 LCCG primary school menus. The mean ± SD, of each macronutrient, CHO, protein and total fat and micronutrients, sodium and calcium are reported, plus energy kcal. The results are then compared to assess how primary school meals have changed nutritionally, and the statistical significance is reported. Findings from both current 2012 and historic 2002 menus are then compared to GNBS.

4.2 Energy Content

Using WND analysis, the total energy in kcal per daily average school meal was derived from both 2002 & 2012 LCCG menus. The 2002 menu analysis revealed a mean total energy content of 567 ± 134 kcal / meal (mean ± SD), and the 2012 menu analysis revealed a mean total energy content of 410 ± 46.1 kcal / meal (mean ± SD). Independent-samples t-tests were conducted to compare the differences between mean energy kcal, of both 2002 & 2012 menus. A significant energy difference was detected between 2002 menu and 2012 menu ($p<0.001$ (two-tailed), mean difference= -161.56, 95% CI: - 238.76 to -84.35). One-sample t-tests were conducted to compare the differences between the mean energy content kcal, derived from both 2002 & 2012 menus, with GNBS. Results showed that no significant difference was detected between 2002 menu and GNBS ($p<0.308$ (two-tailed), t (14) = 1.06, (mean difference = -36.63, 95% CI: -37.68 to 110.94). Whereas a significant difference was detected between 2012 menu and GNBS ($p<0.001$ (two-tailed), t (14) = -10.43, (mean difference = -119.45, 95% CI: -144.02 to -94.89). Therefore, the mean value derived from the 2002 met the GNBS 530 Kcal, ± 5%; however, the mean value derived from the 2012 menu did not meet the GNBS.

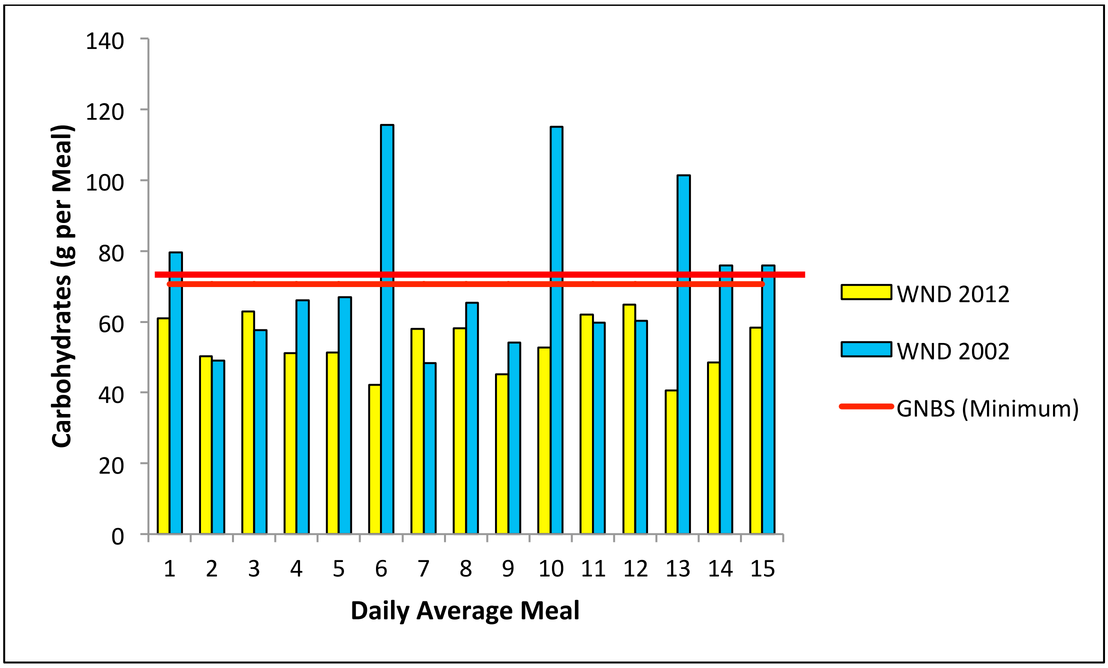


Significance Level set at $P < 0.05$

Figure 4.1 - Bar chart showing the energy content kcal per daily average school meal, derived from the WND analysis of both 2002 & 2012 LCCG primary school menus, and compared to GNBS.

4.3 Carbohydrate Content

Using WND analysis, the total carbohydrate (CHO) in (g) per daily average school meal was derived from both 2002 & 2012 LCCG menus. The 2002 menu analysis revealed a mean CHO content of 72.76 ± 21.89 g / meal (mean ±SD), and the 2012 menu analysis revealed a mean CHO content of 53.80 ± 7.62 g / meal (mean ±SD. Independent-samples t-tests were conducted to compare the differences between mean CHO (g) of both 2002 & 2012 menus. Results revealed a significant difference between 2002 menu and 2012 menu (p<0.006 (two-tailed), mean difference= -18.93, 95% CI: - 31.53 to -6.33). One-sample t-tests were conducted to compare the differences between the mean CHO g per meal derived from both 2002 & 2012 menus, with GNBS. Results revealed that there was no significant difference detected between 2002 menu and GNBS (p<0.711 (two-tailed), t (14) =0.378, (mean difference = 2.13, 95% CI: -9.98 to 14.25). Whereas a significant difference was detected between 2012 menu and GNBS (p<0.001 (two-tailed), t (14) = -8.53, (mean difference = -16.80, 95% CI: -21.02 to -12.57). Therefore, the mean value derived from the 2002 met the GNBS 70.60 g per meal; however the mean value derived from the 2012 menu did not meet the GNBS.

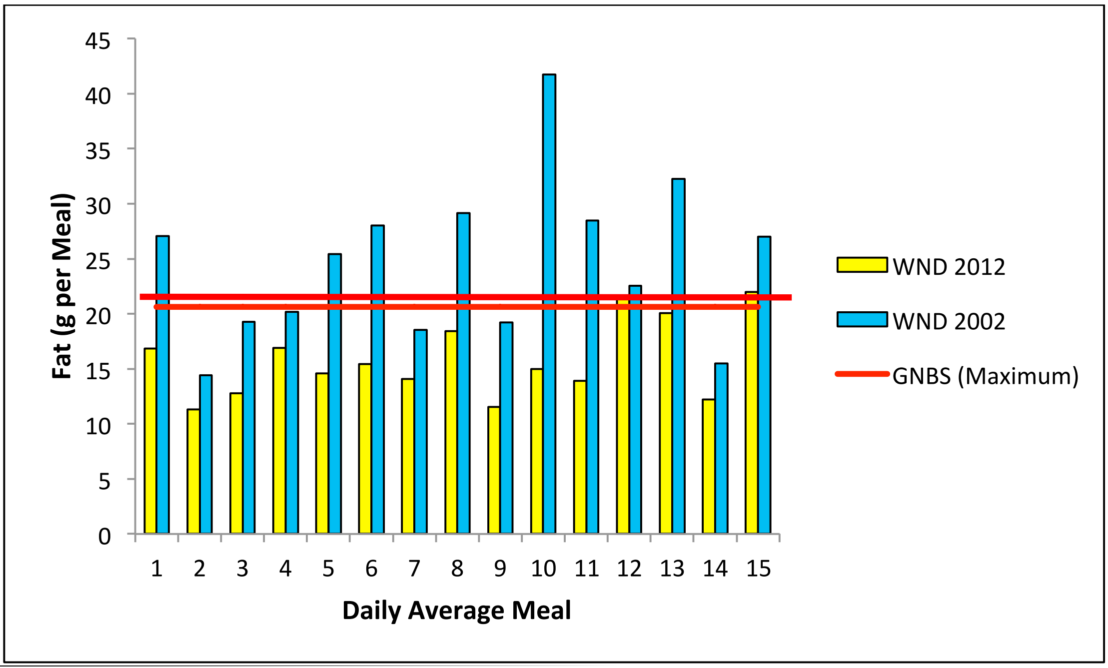


Significance Level set at $P < 0.05$

Figure 4.2 - Bar chart showing the carbohydrate (g) per daily average school meal, derived from the WND analysis of both 2002 & 2012 LCCG primary school menus, and compared to GNBS.

4.4 Total Fat Content

Using WND analysis, total fat in (g) per average daily school meal was derived from both 2002 & 2012 LCCG menus. The 2002 menu analysis revealed a mean total fat content per meal of 24.59 ± 7.16 g / meal, (mean ±SD), and the 2012 menu analysis revealed a mean total fat content of 15.78± 3.47 g / meal (mean ±SD). Independent-samples t-tests were conducted to compare the differences between mean total fat (g) for both 2002 & 2012 menus. Results revealed a significant difference between 2002 menu and 2012 menu ($p<0.001$ (two-tailed), mean difference= -8.80, 95% CI: - 13.08 to -4.52). One-sample t-tests were conducted to compare the differences between the mean total fat g per meal derived from both 2002 & 2012 menus, with GNBS. Results revealed that a significant difference was detected between 2002 menu and GNBS ($p<0.049$ (two-tailed), t (14) = 2.16, (mean difference = -3.99, 95% CI: 0.024 to 7.95). A significant difference was also detected between 2012 menu and GNBS ($p<0.001$ (two-tailed), t (14) = -5.38, (mean difference = -4.82, 95% CI: -6.74 to -2.90). Therefore, the mean value derived from the 2002 menu exceeded the maximum GNBS 20.60g per meal; however the mean value derived from the 2012 menu did not exceed the maximum GNBS.

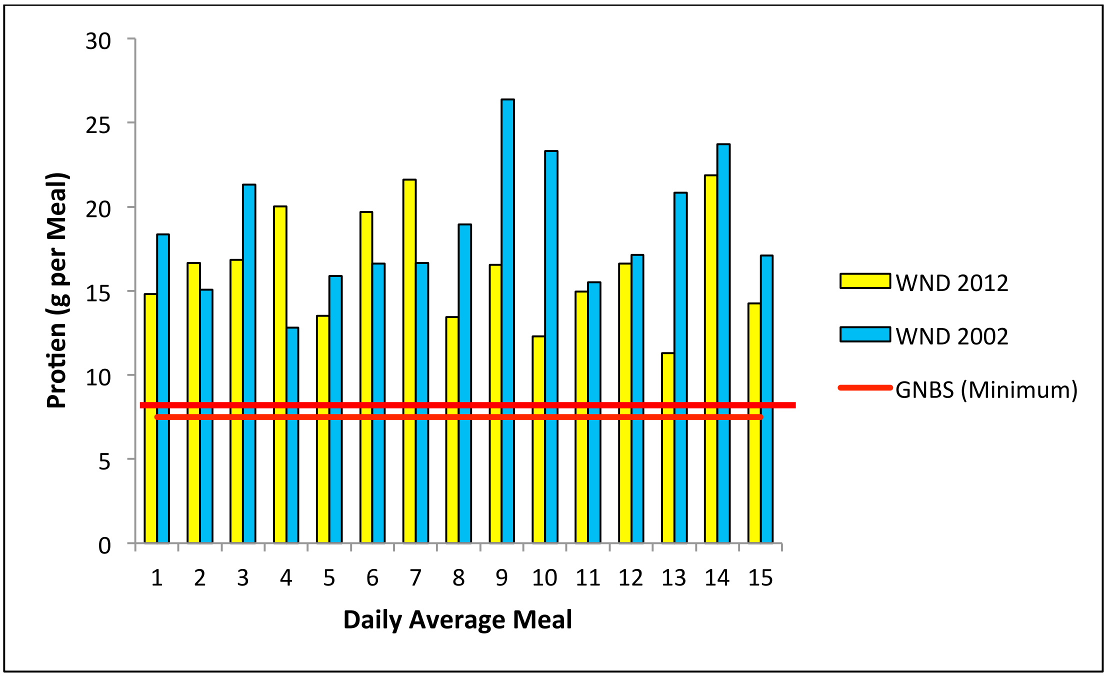


Significance Level set at *P* < 0.05

Figure 4.3 - Bar chart showing the total fat (g) per daily average school meal, derived from the WND analysis of both 2002 & 2012 LCCG primary school menus, and compared to GNBS.

4.5 Protein Content

Using WND analysis, the total protein (g) per average daily school meal was derived from both 2002 & 2012 LCCG menus. The 2002 menu revealed a mean protein content per meal of 18.65 ± 3.75g / meal (mean ± SD), and the 2012 menu revealed a mean protein content per meal of 16.30 ± 3.27g / meal (mean ± SD). Independent-samples t-tests were conducted to compare the differences between mean protein (g) for both 2002 & 2012 menus. Results revealed that there was no significant difference detected between 2002 menu and 2012 menu ($p<0.078$ (two-tailed), mean difference= -2.35, 95% CI: - 4.99 to 0.29). One-sample t-tests were conducted to compare the differences between the mean total fat g per meal derived from both 2002 & 2012 menus,with GNBS. Results revealed that a significant difference was detected between 2002 menu and GNBS ($p<0.001$ (two-tailed), t (14) = 11.51, (mean difference = 11.15, 95% CI: 9.07 to 13.23). A significant difference was also detected between 2012 menu and GNBS ($p<0.001$ (two-tailed), t (14) = 10.42, (mean difference = 8.80, 95% CI: 6.99 to 10.61. Therefore, both values derived from the 2002 and 2012 menu WND analysis were significantly higher than the minimum GNBS 7.5g.

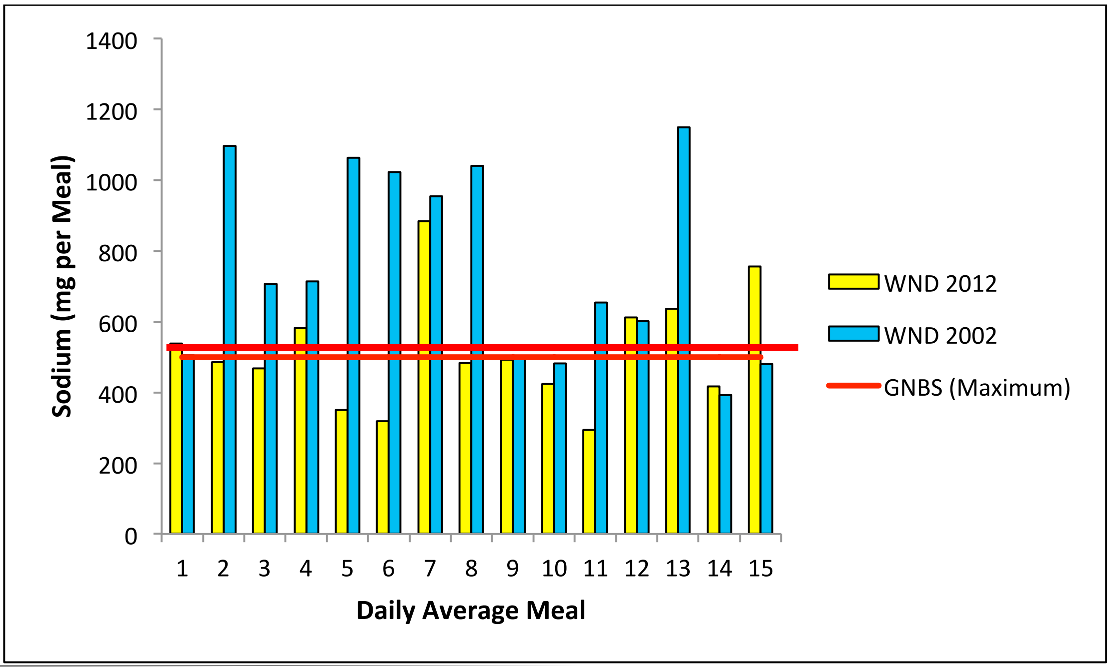


Significance Level set at *P* < 0.05

Figure 4.4 - Bar chart showing the protein (g) per daily average school meal, derived from the WND analysis of both 2002 & 2012 LCCG primary school menus, and compared to GNBS.

4.6 Sodium Content

Using WND analysis, the total Sodium (mg) per daily average daily school meal was derived from both 2002 & 2012 LCCG menus. The 2002 menu revealed a mean sodium content per meal of 757.67 ± 268.44 mg / meal (mean ± SD), and the 2012 menu revealed a mean sodium content per meal of 515.85 ± 160.18 mg / meal (mean ± SD). Independent-samples t-tests were conducted to compare the differences between mean sodium mg, for both 2002 & 2012 menus. Results revealed that a significant difference was detected between 2002 menu and 2012 menu ($p<0.006$ (two-tailed), (mean difference= -241.85, 95% CI: - 408.86 to -74.80). One-sample t-tests were conducted to compare the differences between the mean sodium mg per meal derived from both 2002 & 2012 menus, with GNBS. Results revealed that a significant difference was detected between 2002 menu and GNBS ($p<0.002$ (two-tailed), t (14) = 3.73, (mean difference = 258.67, 95% CI: 110.01 to 407.33). Results revealed, there was no significant difference detected between 2012 menu and GNBS ($p<0.690$ (two-tailed), t (14) = 0.407, (mean difference = 16.85, 95% CI: -71.86 to 105.55). Therefore, the mean value derived from the 2002 menu exceeded the maximum GNBS 499mg per meal and though the mean value derived from the 2012 menu did exceed the maximum GNBS, it wasn't significantly different.

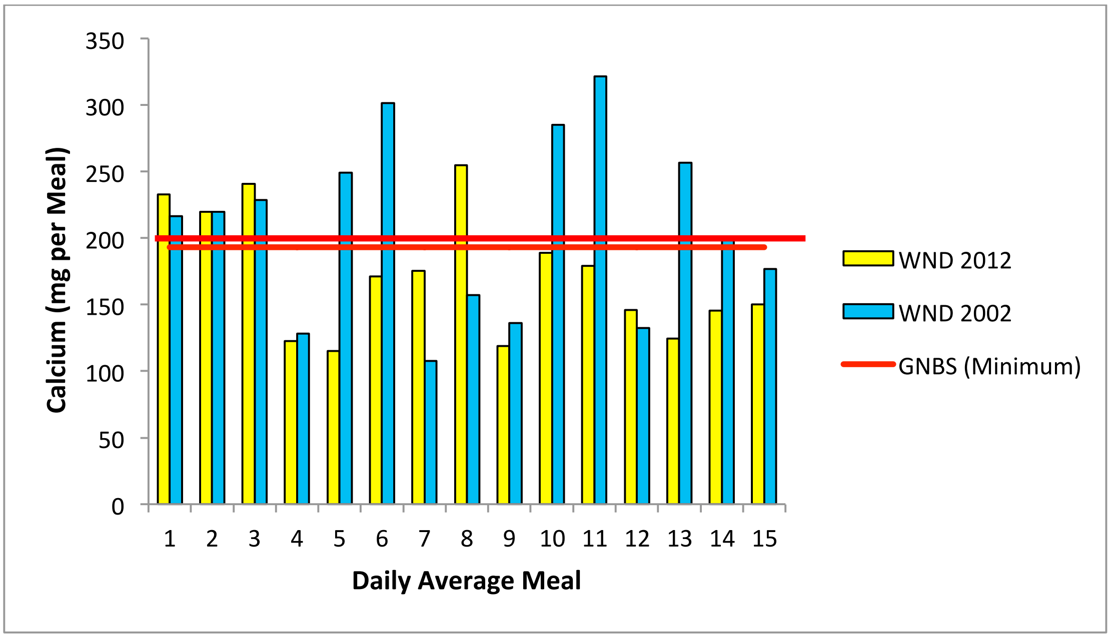


Significance Level set at $P < 0.05$

Figure 4.5 - Bar chart showing the Sodium (mg) per daily average school meal, derived from the WND analysis of both 2002 & 2012 LCCG primary school menus, and compared to GNBS.

4.7 Calcium Content

Using WND analysis, the total calcium (mg) per daily average daily school meal was derived from both 2002 & 2012 LCCG menus. The 2002 menu revealed a mean calcium content per meal of 207.86 ± 67.20 mg / meal (mean ± SD), and the 2012 menu revealed a mean calcium content per meal of 172.44 ± 46.75 mg / meal (mean ± SD). Independent-samples t-tests were conducted to compare the differences between mean calcium mg, for both 2002 & 2012 menus. Results revealed that a significant difference was detected between 2002 menu and 2012 menu ($p<0.105$ (two-tailed), mean difference= -35.42, 95% CI: - 78.71 to -7.88). One-sample t-tests were conducted to compare the differences between the mean calcium mg per meal derived from both 2002 & 2012 menus, with GNBS. There was no significant difference detected between 2002 menu and GNBS ($p<0.406$ (two-tailed), t (14) = 0.856, (mean difference = 14.86, 95% CI: -22.35 to 52.07). There was also no significant difference detected between 2012 menu and GNBS ($p<0.111$ (two-tailed), t (14) = -1.703, (mean difference = -20.56, 95% CI: -44.45 to 5.33). Therefore, the mean value derived from the 2002 menu would have met the minimum GNBS 193 mg per meal; however, the mean value derived from the 2012 menu did not meet the minimum GNBS.



Significance Level set at $P < 0.05$

Figure 4.6 - Bar chart showing the Calcium (mg) per daily average school meal, derived from the WND analysis of both 2002 & 2012 LCCG primary school menus, and compared to GNBS.

4.8 Summary

In summary, the WND analysis of both the historic 2002 and the 2012 LCCG school menu produced values which were both positive and negative for school nutrition provision. The WND analysis of the LCCG menus revealed that the mean energy per meal which was provided to primary school children in 2002 was closer to the minimum GNBS than the energy per meal offered by the 2012 LCCG menu. These findings were also observed by a plethora of other studies that have evaluated school meals and revealed a lower energy content (Rees *et al*, 2008, SFT, 2008). However, a study by Haroun *et al*, 2010, observed a mean energy content of 626.3 kcal per meal in 136 primary schools, interestingly only 24 schools met the minimum GNBS, suggesting significant variability in energy content.

The LCCG 2012 menus revealed that both total fat and CHO content per meal, has decreased significantly since 2002, which would explain the lower energy value revealed at 567 kcal / meal 2002, to 410 kcal / meal in 2012. Total fat values per meal have revealed a significant reduction since 2002 at a mean 24.59g / meal, to 15.78g / meal in 2012, while CHO values have shown a reduction from 72.76 g / meal in 2002 to 53.80 g / meal in 2012. A decrease in CHO content is not necessarily welcome as CHO should provide the main source of energy in the diet (SFT, 2006); however these findings may be attributed to a reduction in Non Milk Extrinsic Sugars (NMES). Though this study did not analyse NMES content, other studies have reported a significant reduction in NMES content since the introduction of the GNBS (SFT, 2008, SFT, 2009). Furthermore other studies have suggested that a school meal which is lower in total energy may not necessarily be unwelcome in light of the increase in childhood obesity (Gregory *et al*, 2000, Rogers *et al*, 2007, SFT, 2009a).

Both menus reported values which were significantly higher than the minimum GNBS for protein, these findings have been observed by the majority of other studies (SFT, 2009a, Haroun *et al*, 2010, SFT, 2008, McGuffin *et al,* 2010). Values reported for calcium for both menus reported only slightly different values, which were not significantly different than the recommended GNBS. The 2002 LCCG menu revealed significantly high sodium values; however these values have shown significantly improvement in the 2012 menu analysis, though there is still room for improvement.

CHAPTER 5

THE IMPACT OF A MID-MORNING SNACK ON CHILDREN'S COGNITIVE FUNCTION:

RESULTS

5.1 Overview of Chapter

In this chapter the findings address aim 3, the investigation into the impact of a mid-morning snack on a child's cognitive function (concentration and memory). Section 1, presents the number of children who participated in, and completed both cognitive tests, and also explains the scoring procedure. Section 2, presents the results derived from both cognitive performance tests 1 (Pre-snack, which was before pupils had consumed their mid-morning snack) and test 2 (Post-snack, which was performed after pupils had consumed their mid-morning snack) and will be displayed in table 3**.** Section 3 will report the statistical analysis of the cognitive test results, with any observations. Finally, this chapter will finish by summarising the findings in this chapter.

5.2 Tests Completed

Thirty five, year 2 pupils (aged 6-7) were invited to participate in a short term memory test. Consent forms were provided to all parents of pupils, and none of the parents declined. A total of 24 pupils returned signed consent forms and 11 pupils did not, this was recorded as a decline. A total of 21 pupils (10 girls and 11 boys) completed testing as (2 girls and 1 boy) missed testing due to ill health. Children were assessed with a three tier scoring method; firstly 1 mark was given for a circling of a picture identified correctly, secondly 1 mark was removed for an incorrect circling of a picture and thirdly a half mark was removed for no answer, as this was neither correct nor incorrect.

Table 5.1 - This table displays the cognitive performance scores produced in test 1 (Pre-snack, which was before pupils had consumed their mid-morning snack) and in test 2 (Post-snack, which was performed after pupils had consumed their mid-morning snack).

Subject Number	Test 1. Pre-Snack/ Scores				Test 2. Post-Snack/ Scores			
	Correct	No Answer	Incorrect	Total Score	Correct	No Answer	Incorrect	Total Score
1	9.0	0	1.0	8.0	10.0	0	0	10.0
2	5.0	5.0	0	2.5	10.0	0	0	10.0
3	10.0	0	8.0	2.0	8.0	0	2.0	6.0
4	8.0	0	2.0	6.0	10.0	0	1.0	9.0
5	8.0	0	2.0	6.0	10.0	0	0	10.0
6	9.0	0	2.0	7.0	9.0	0	2.0	7.0
7	8.0	2.0	0	6.0	10.0	0	0	10.0
8	8.0	0	3.0	5.0	10.0	0	0	10.0
9	8.0	2.0	0	7.0	9.0	1.0	0	8.5
10	9.0	0	2.0	7.0	9.0	1.0	0	8.5
11	9.0	1.0	0	8.5	10.0	0	0	10.0
12	10.0	0	8.0	2.0	10.0	0	4.0	6.0
13	8.0	2.0	0	7.0	9.0	0	1.0	8.0
14	8.0	2.0	0	7.0	10.0	0	0	10.0
15	7.0	2.0	1.0	5.0	9.0	0	2.0	7.0
16	8.0	0	2.0	6.0	10.0	0	1.0	9.0
17	7.0	0	4.0	3.0	9.0	0	2.0	7.0
18	9.0	0	2.0	7.0	10.0	0	2.0	8.0
19	10.0	0	10.0	0	10.0	0	2.0	8.0
20	10.0	0	0	10.0	10.0	0	0	10.0
21	9.0	0	1.0	8.0	10.0	0	0	10.0
Mean	8.43	0.76	2.29	5.71	9.62	0.09	0.90	8.67

5.3 Statistical Analysis

Statistical analysis was conducted to compare the differences between cognitive performance scores recorded for test 1 and test 2. Test 1 reported a mean score of 5.81 ± 2.58 (mean ± SD), and test 2 reported a mean score of 8.67 ± 1.42 (mean ± SD). Data was assessed for normality using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. As results were significant suggesting a violation of the assumption of normality, a non-parametric test Wilcoxen signed rank test was used to assess differences between test 1 and test 2. A statistically significant difference was revealed between the scores. $z = -3.83$, $p < 0.001$ (two-tailed), with a large effect size ($r = 0.59$). The median score on the effect of a mid-morning snack on cognition scale increased from pre-snack ($Md = 7$) to post-snack ($Md = 9$). Statistical significance level was set at $p \leq 0.05$.

5.4 Summary

In summary, the results revealed by the cognitive testing suggest a significant improvement in cognitive function of primary school children, following the intake of a mid-morning snack. The results are discussed in further detail in the discussion pg 101.

CHAPTER 6
DISCUSSION

6.1 Overview of this chapter

This study was designed to investigate and evaluate the provision of school nutrition in primary schools, concentrating on the county of Lancashire. This chapter will begin by discussing the findings that address Aim 1, the investigation as to whether nutrition provision in Lancashire primary schools meets the GNBS. The mean totals per meal, for energy, carbohydrate, total fat, protein, sodium and calcium will be discussed, with reference to GNBS. Nutrients which fail to meet the GNBS will be highlighted, and the possible implications will be discussed with regard to children's health, and further recommendations will be suggested. Aim 2, to assess whether school meals provided by LCCG, have improved nutritionally over the ten year period 2002-2012 will be discussed, and the nutrient analysis will be compared to GNBS, 2007, and relevant current research. Aim 3, the impact of a mid-morning snack on cognitive function, results of the cognitive memory tests will be compared and possible reasons for these findings will be discussed and related to relevant research. Finally, methodology and analysis will be discussed with reference to limitations and strengths, and the chapter will finish with a brief conclusion and suggestions for future research.

6.2 Aim 1: Analysis of Primary School Meals, Compared to GNBS

6.2.1 Macronutrients provided per meal

Analysis of the nutritional content of the school meals provided to primary school children in Lancashire by LCCG revealed that macronutrients total fat and protein conformed to GNBS, whereas carbohydrate was outside the recommended guidelines.

6.2.1.1 Total Fat content

Both the laboratory and WND analysis revealed that the mean total fat content of the LCCG school meals provided to primary aged children did not exceed the maximum recommended GNBS. Generally earlier studies, for example The Soil Association's research into the nutritional content of school meals, reported a high fat content which meant that school meals failed to meet nutritional guidelines (The Soil Association, 2003). A later study by Rees *et al*, 2008, a nutrient comparison between primary school meals and packed lunches reported that children having school meals on average consumed more total fat than those having packed lunches, however he also reported that school meals were lower in saturated fatty acids than packed lunches, and both meal types did not exceed the GNBS. Generally, most current studies have recorded a significant reduction in the fat content of primary school meals, which is in line with this present study. The school food trust, 2008, investigated whether school meals met GNBS in six Sheffield primary schools; both school meals and packed lunches were assessed. Results revealed that school meals mean total fat (14.7g) did not exceed the maximum GNBS, whereas packed lunches exceeded the maximum GNBS, mean (29.8g) (SFT, 2008). Again findings agree with the research undertaken by McGuffin *et al* 2011, which reported that three UK primary schools investigated did not exceed the GNBS 20.6g maximum for total fat. However in this study there was great variability in the meal results, '12.9g-30.4g', these results could in effect be unhealthy meals for children if they chose a high fat meal every day. It is important that school meals do not exceed the maximum GNBS, as a diet high in saturated fatty acids can lead to heart disease, diabetes and some cancers. However essential fatty acids are needed in the diet, either in the form of oily fish or polyunsaturated margarines as it cannot be produced in the body. Though the LCCG school menu offered fish between once and three times a week, oily fish was only offered on the menus once in three weeks. Though it is important to consume essential fatty acids in the diet, intake needs to be regulated as it is currently recommended that females under fifteen years should not consume more than two portions of oily fish per week in total. (http://www.nhs.uk/Livewell/Goodfood/Pages/fish-shellfish).

6.2.1.2 Protein content

Both the laboratory and WND analysis of LCCG school meals revealed that the mean protein values for each meal exceeded the minimum GNBS of 7.5g; with on average a 50% increase on the recommended value of 7.5g. Many other studies have also reported similar high protein content in their analysis of school meals (Gregory *et al*, 2000, Brighton, 2005). A large study which was funded by the FSA (Food Standards Agency), investigated the quality school meals in primary schools in England, and though it was found that only 23% of the school meals selected met the required GNBS recommendations, findings revealed that 97% of pupils chose meals which still exceeded the minimum recommended GNBS for protein (Nelson *et al*, 2006). A study by Haroun *et al,* 2010, investigated the impact that GNBS had on nutrition provision in primary schools in the UK; results reported that the average protein content of primary school meals exceeded the minimum recommendations at (23.7g). Rees *et al*, 2008, recorded the protein intake of primary aged children consuming school meals and reported that results exceeded the minimum recommended standard for protein at mean (18g). These results were also replicated in both School Food Trust studies (SFT, 2008 & 2009a). It is known that protein is important for children as it is needed for the repair of body cells and tissues and as children are growing fast, protein is of particular importance at this stage. Although the GNBS recommend that the minimum protein intake should be met, they do not recommend a maximum intake (GNBS, 2007). However the CWT (Caroline Walker Trust) nutritional guidelines suggested that excessive intakes of protein are of no benefit to children, and it would be prudent to avoid protein intakes greater than twice the minimum RNI (CWT, 2005). It has been suggested that excessive protein intakes may be linked to certain health risks such as demineralisation of the bone (Heaney, 2002, Feskanich *et al,* 1996) though this research is inconclusive. It is important that protein is derived in the diet from a selection of sources, to ensure all essential amino acids are obtained.

The LCCG menu includes an abundant supply of foods containing protein; most daily menu's included different forms of meat, cheese, yogurt and fish, this is shown in the mean protein values which exceed the minimum GNBS. However, though this current study did not investigate the relationship between primary school meals and vegetarian children, it should be noted that they are at a greater risk of a poor protein intake (Geissler & Powers, 2009). The majority of the protein choices available to vegetarians on the LCCG menu are dairy products; however specific vegetarian dishes were available twice throughout the three week menu collection. There may be a lack of adequate protein sources on offer; ideally protein intake should come from more than one source to achieve a good balance of essential amino acids, however there are also different types of vegetarian diets which would make some diets more restricted than others.

6.2.1.3 Carbohydrate content

The laboratory and WND analysis revealed that the mean carbohydrate content of the school meal was 52.66g and 53.67g per meal respectively. These values indicated that the LCCG school meals which were provided to primary aged children did not meet the minimum recommended GNBS. Starchy carbohydrate should form the main component and the main source of energy of the school meal (School food trust, 2006). These results are consistent with the majority of studies published which have reported that primary school meals contain low carbohydrate content. The school food trust, 2008, investigated whether school meals met GNBS in six Sheffield primary schools. Results reported the school meals mean total carbohydrate content at 61.6g per meal which is a slight increase on this current study, but still below the minimum recommended GNBS. Another study by McGuffin *et al*, 2011, reported that the mean carbohydrate content for three UK primary schools met GNBS, however there was great variability in carbohydrate content, '47.8g-102.9g'.

In this current study we analysed school meal provision, however some studies have also recorded school meal consumption which reported interesting results. The School food trust, 2009a, assessed the nutritional provision and consumption of school meals served in 136 primary schools. Findings were significantly different, reporting a mean total carbohydrate content of 90.3g per meal, which was much higher than the minimum recommended standard. However, the mean intake was recorded at 53.7g per meal, suggesting that children were not consuming the whole school meal. A study by Rees *et al*, 2008, also reported the carbohydrate intake of primary aged children consuming school meals, as mean total 52g per meal. Interestingly, both of these studies reported school meal consumption to be around the same value as school meal provision reported in this current study. Another study which recorded school meal consumption reported that the reason for low nutritional intake was that children only ate the foods they liked, and often vegetables and potatoes were wasted (Gattenby, 2008). These findings may suggest that even if children are provided with the recommended standard meal, it doesn't mean it will be consumed. As stated by the 1975 Department for Education Science report 'a nutritious meal will only benefit pupils if they eat it' (DES, 1975). Complex carbohydrates are especially important for school children, as they are the main fuel for brain function; the LCCG menu already includes starchy carbohydrates, such as potatoes, rice and pasta. As reported earlier pg 80, a reduction in the CHO content of primary school meals could be attributed to a reduction in Non Milk Extrinsic Sugars (NMES). Furthermore, though this study did not analyse NMES content, other studies have reported a significant reduction in NMES content since the introduction of the GNBS (SFT, 2008, SFT, 2009).

6.2.2 Micronutrients provided per meal

6.2.2.1 Sodium Content

The laboratory and WND analysis revealed that the mean sodium content of the school meals was 500 mg and 516 mg per meal respectively, both showing results above the maximum recommended 499 mg GNBS, 2007 but not significantly. Research regarding the sodium content of school meals has reported consistent findings, many studies pre- GNBS, 2007 reported that school meals contained high levels of sodium and that children generally consumed too much sodium (The Soil Association, 2003, FSA, 2002). Stevens & Nelson, 2011, evaluated dietary information which had been collected between 2003 -2005 from 932 children, at this time there was no requirement for school meals to adhere to nutrient based standards. Findings reported that school meals would have failed to meet the maximum GNBS, even without taking into account salt which could be have been added at the table into consideration. However a more recent study by McGuffin *et al*, 2011, which investigated the nutritional composition of school meal provision, in three primary schools in the UK, also reported that school meals failed to meet the current maximum recommendations for sodium intake in all three schools, at a mean of 573 mg per meal. The school food trust survey, 2008, investigated whether school meals met GNBS in six Sheffield primary schools. Again this study reported a sodium mean of 523 mg per meal, which again was above the maximum recommended standard. The School food trust, 2009a, undertook a survey which assessed the nutritional content of school meals served in 136 primary schools. Findings yielded from this study reported that the sodium levels were higher than the maximum recommendations at a mean of 556mg per meal. Interestingly this study also recorded the sodium consumed at a mean 465mg per meal, which was just slightly below the maximum recommended standard. However, another study by Rees *et al*, 2008 which also recorded the sodium intake of primary aged children consuming school meals, reported results that exceeded the maximum GNBS at a mean of 542mg per meal. It seems that even when consumption is reported rather than provision, school meals are still exceeding the maximum GNBS for sodium intake per meal.

The high sodium content of primary school meals is of particular concern as it is linked to high blood pressure, which can lead to coronary heart disease, stroke and kidney disease (Dare & O'Donovan, 2002). Research also shows that a diet high in sodium can also cause calcium losses through urination, which can lead to bone demineralisation increasing the risk of osteoporosis (Cappuccio, *et al,* 2000). Sodium is easily obtained from a healthy diet; the school meals supplied by LCCG exceed the recommended standard. On collection of the LCCG school meals, it was observed that cheese was available on the menu almost everyday of the three week menus. It would be recommendable to reduce the amount of cheese available, as the average cheese contains about 66% sodium per 100g. Research has shown that some cheeses contain more sodium than a bag of crisps (CASH, 2012).

6.2.2.2 Calcium Content

An adequate intake of calcium throughout childhood is extremely important for the development of peak bone mass; children are at most risk of deficiency when they are growing most rapidly. The laboratory and WND analysis revealed that the mean calcium content of the school meals was 210 mg and 171mg per meal respectively, showing results above and below the minimum recommended 193mg per meal GNBS, 2007, however not significantly different. Micronutrients such as sodium can be easily obtained in the diet; however achieving DRV's for intakes of other micronutrients such as calcium may be more difficult. Early research in England schools, reported that school meals were very low in certain micronutrients such as calcium (DH, 1983). However, later research regarding the calcium content of school meals has reported conflicting findings. The School food trust, 2009a, assessed the nutritional content of school meals served in 136 primary schools. Results revealed that the mean calcium values exceeded the minimum GNBS at a mean of 208 mg per meal, which was higher than the current study. McGuffin *et al*, 2011 agreed with the current study only in part, as one of the three primary schools they had analysed failed to meet the minimum standard for calcium, however this was not significant. However, a study by Rees *et al*, 2008, reported that primary aged children who consumed school meals were receiving significantly less calcium than those who consumed packed lunches. However they suggested that this wasn't because calcium rich foods were not being provided, it was because children were not choosing the calcium rich foods which were on offer to them (Rees *et al*, 2008). The main sources of calcium available in the diet are dairy products and the LCCG menu includes an abundant supply of foods containing calcium. Most of LCCG menu's included different forms of dairy daily, including cheese which was available almost everyday, milk and yogurt which was also on the menu every day. Although this current study did not investigate vitamin D content, it must be noted that vitamin D is needed for calcium absorption, and there are very few foods which contain vitamin D on the LCCG menu.

6.2.2.3 Iron content per meal

Iron content of school meals are reported for WND analyses only, as the laboratory findings could not be reported due to probable contamination. WND analysis revealed that the mean iron content of the school meals was 1.87 mg per meal, which was significantly below the minimum recommended 3 mg GNBS, 2007. These results are consistent with a plethora of studies published which have reported that primary school meals contain significantly low iron content (SFT, 2008, SFT, 2009a, Haroun *et al*, 2010, Rees *et al*, 2008, McGuffin *et al*, 2011, Pearce *et al*, 2009, Gattenby, 2007, Buttriss, 2002, & Evans *et al*, 2010). Early research in England schools, reported that school meals were very low in certain micronutrients such as iron (DH, 1983), and as research suggests school meals are consistently failing to meet the GNBS recommended iron content, which is necessary for a growing child. Iron is needed for both the production of red blood cells and a healthy immune system, and as discussed earlier (pg

18), depletion of iron stores can lead to psychological changes and impaired learning and cognition (Geissler & Powers, 2009). The School food trust, 2009a, assessed the nutritional content of school meals served in 136 primary schools. Results revealed that the mean iron failed to meet the minimum GNBS at a mean of 1.9 mg per meal, very similar to the findings of the current study. McGuffin *et al*, 2011 agreed with the current study only in part, however two out of the three primary schools they had analysed failed to meet the minimum standard for iron at a mean 2.6, 2.3 & 3mg per meal, which were significantly lower than the GNBS.

The best source of iron is red meat, however GNBS state that red meat is only required to be offered twice a week, on other days the LCCG menu offered some lower iron choices on some days such as chicken and fish. As discussed earlier, pg 88, though this current study did not investigate the relationship between primary school meals and vegetarian children, it should be noted that they are at a greater risk of a poor iron status (Geissler & Powers, 2009). The best sources of iron for vegetarians are green leafy vegetables, eggs, peas, brown rice, various beans and dried apricots and raisins GNBS. However, throughout the three week menu collection, a specific vegetarian sausage & ravioli dish was served twice, beans three times, eggs once and peas once, suggesting that further attention is needed regarding the vegetarian diet.

6.2.3 Energy content per meal

The laboratory and WND analysis revealed that the total energy content of the LCCG school meals provided to primary aged children, revealed a mean 392 kcal and 411 kcal per meal respectively, which fell significantly below the minimum GNBS. Many studies that have researched this area have reported both the provision and consumption of school meals. The School food trust, 2009a, assessed the nutritional content of school meals provided and consumed in 136 primary schools. Findings reported mean values for infants and juniors at between 490 kcal and 503 kcal per meal which met the GNBS. Interestingly when the same school meals were reported as consumed, the mean intake was significantly lower at 378kcal and 410 kcal per meal (SFT, 2009a), which was more in line with the current study. A study by Rees *et al*, 2008, compared nutrient consumption of primary school meals with packed lunches; they reported that children eating school meals consumed a mean energy total of 440 kcal. A further school meal survey undertaken by the school food trust, 2008, assessed the consumption of both school meals and packed lunches in six Sheffield primary schools. Findings reported were very like the current study values, in which school meals failed to meet the recommended energy standard at a mean of 435 kcal per meal (SFT, 2008). As discussed earlier, it seems that even if children are provided with the recommended standard meal, it doesn't mean it will be consumed. As Gattenby observed, children tend to only eat the foods they like and often vegetables and potatoes are wasted (Gattenby, 2008).

Research also suggests that there may be significant variability in meal portion sizes being served in our schools, and that this will have an effect on the nutrient intake of children (Howell *et al*, 2008). Though regulations for school meal portion size are specified, (DfEE, 2000), a study by Davies *et al*, 2008, found significant variation in school meal portion sizes and that these issues were three fold. Firstly, findings suggested that pupils would be served larger portions at the beginning of the service compared to the end, as supplies may begin to run out. Secondly, that less popular food items would be served in larger portions to avoid wastage, and third, catering staff tended to serve larger portion sizes to children they favoured and also to children who had a higher body mass index (BMI) (Davies *et al,* 2008). A study by McGuffin *et al*, 2011, investigated the nutritional composition of school meal provision in three primary school in the UK, reported that though school meals met the current energy intake recommendations, there was great variability between meal energy totals at 394 kcal- 697 kcal per meal.

6.2.4 School meal composition

The FSA advise that the school meal should aim to provide about 30% of daily total energy intake, breakfast and evening about 50% and snacks about 20%. The GNBS for total energy for the school meal advise this to be about 530 Kcal, $\pm$ 5% per school meal. In this current study, the analysis of LCCG school meal provision reported total energy at a mean of 392 kcal and 411 kcal per meal, which would provide 74% and 77.5% of the recommended GNBS. As discussed earlier pg 95, this could be due to variable portion size Howell *et al*, 2008, however it could also be due to meal composition. The FSA state that a healthy balanced diet will consist of around 55- 60% carbohydrate from energy,30 -35% from total fat and about 10-15% from protein (FSA, 2006).

When the nutrient values derived from the school meal analysis were converted to % of energy, findings revealed carbohydrate content to be at 71.8% and 62.6%, which was in part significantly higher than the advised 55-60%. The % total fat content was reported at 11.2% and 18.4%, which was significantly lower than the advised maximum 35% and the % protein content was reported at 17.8% and 19%, which was not significantly different (FSA, 2006). This indicates that if the portion size were to be increased to meet the GNBS of 530 Kcal, $\pm$ 5% per school meal, CHO and protein content would be slightly higher than recommended and % total fat would be significantly lower than recommended by the FSA. Higher % carbohydrate content is not necessarily unwelcome, because as discussed earlier, complex carbohydrates are especially important for school children, as they release glucose slowly into the bloodstream and aid cognitive function, helping children to concentrate and achieve at school, however carbohydrates are a less concentrated form of energy than fat.

Fat content was highlighted by the Department of Health as a nutrient which needed to be reduced in the diet, as it was reported that 90% of children were eating more saturated fatty acids than recommended (NHS, 2000, DH, 2004). However as discussed earlier pg 87, essential fatty acids are needed in the diet in the form of oily fish or polyunsaturated margarines as it cannot be produced in the body. However regulation of consumption is needed as it is currently recommended that females under fifteen years should not consume more than two portions of oily fish per week in total. (http://www.nhs.uk/Livewell/Goodfood/Pages/fish-shellfish).

Research has also observed that school meal consumption is significantly lower than school provision, suggesting that children are not eating the whole meal (SFT, 2009a). A survey by Brighton, 2005, suggested that children may consume more energy at other times of the day outside of school. Therefore it has been suggested that a school meal which is lower in total energy, may not necessarily be unwelcome in light of the increase in childhood obesity (Gregory *et al*, 2000, Rogers *et al*, 2007, SFT, 2009a), however this would mean that the school meal would need to be more nutrient dense in order to meet GNBS for other nutrients.

Micronutrients calcium and sodium were converted into mg/kcal; results indicated that the minimum GNBS calcium content was met per kcal. However when sodium levels were converted into mg/kcal; results indicated that sodium levels were significantly higher than the maximum GNBS. Many studies have shown that children consume too much sodium in their diet (Brighton, 2005, The Soil Association 2003), and a high intake of sodium in the diet has been said to increase blood pressure which consequently increases the risk of heart disease and strokes(Gregory *et al*, 2000). A diet high in salt can also cause calcium losses through urination, which can lead to bone demineralisation increasing the risk of osteoporosis (Cappuccio, *et al,* 2000).

6.3 Aim 2: A comparison between 2002 and 2012 LCCG menus.

Aim 2, was to assess whether primary school meals have improved nutritionally over the ten year period 2002-2012, which included the implementation of the GNBS, 2007. It is assumed that since the implementation of the GNBS, primary school meals would have improved nutritionally. The WND analysis of both 2002 and 2012 LCCG primary school menus' highlighted that primary school meals have made marked improvements with regard to total fat and sodium, and that protein content still met the recommended standard. However, total energy, carbohydrate and calcium content per meal, have decreased and failed to meet GNBS, 2007.

It is suggested that the nutritional composition of food provided to children should help towards preventing obesity and related health problems, by reducing the total fat, sugar and sodium content (Rudolf *et al,* 2001). A study by Rogers *et al*, 2007, examined the primary school meals and packed lunches of children in 1999 and 2000, and reported that both school meals and packed lunches exceeded the recommended GNBS maximum for total fat. The current study menu analysis demonstrated that the total fat content of LCCG primary school meals has reduced from a mean of 24.59 g per meal in 2002 to a mean of 15.78g per meal in 2012, which no longer exceeds the recommended standard. Sodium levels have also been reduced from a mean of 758 mg per meal in 2002 to a mean of 516 mg per meal in 2012; though this is an improvement it still exceeds the GNBS of 499 mg per meal but not significantly.

Most studies have shown that the protein content in primary school meals exceeds the recommended minimum standard (Nelson *et al*, 2006, Haroun *et al,* 2010, Rogers *et al*, 2007). The protein content of LCCG school meals has not changed significantly from a mean of 18.65g per meal in 2002 to a mean of 16.30g per meal in 2012; however both menus' met the minimum standard of 7.5g per meal. As discussed earlier pg 88, GNBS do not give a maximum recommendation for protein content per meal; however the CWT nutritional guidelines suggested that excessive intakes of protein are of no benefit to children, and it would be prudent to avoid protein intakes greater than twice the minimum RNI (CWT, 2005).

A small number of studies have suggested that a low energy intake in school meals may affect cognitive function, reduce concentration, attention and overall academic achievement (Benton, 2001, Kaiser & Townsend, 2005). The current 2012 menu analysis reported that the mean energy content was significantly below the GNBS at a mean 410 kcal per meal, this result was significantly below the mean energy content offered by the 2002 menu at a mean 567 kcal per meal, which was nearer to the GNBS, 2007. It may be that the energy content of the school meal should be seen is part of a whole daily intake, as nutrient intake ideally should be balanced throughout the day;

however it is important that the school meal should contain sufficient energy and micronutrients, to promote good health for those who are nutritionally vulnerable (SFT, 2013). Furthermore as discussed earlier, some studies have suggested that a school meal lower in energy is not necessarily unwelcome in light of the increase in childhood obesity (Gregory *et al,* 2000, Rogers *et al*, 2007 % SFT, 2009a).

The 2012 menu analysis also demonstrated that CHO content was below the recommended standard, at a mean 53.80g per meal, this result was significantly below the mean CHO content offered by the 2002 menu at a mean 72.76g per meal, which would have met the GNBS, 2007. CHO should be the primary source of energy in the school meal, as it is the body's preferred source of fuel, research has reported that children between the ages 4-10 utilise cerebral glucose at double the rate of adults (Chugani, 1998). Managing macronutrient and micronutrient intakes for primary aged children is somewhat complicated, as research shows that convenience foods which are high in fat, sodium, sugar and low in vitamins and minerals are more frequently consumed outside of school (FSA, 2005).

Ideally the school meal should provide about 50% CHO, preferably complex CHO which will release glucose slowly into the bloodstream and aid cognitive function. There are two main types of CHO, starches and sugars, with starchy CHO providing the main source of energy (SFT, 2006). Non Milk Extrinsic sugars are another form of CHO sugars in the diet, normally found in fruit juice, cakes, pastries sweets etcetera (SFT, 2006). Though this study did not analyse NMES content, the reduction in total CHO content in the 2012 values could in effect be because many of these types of foods are no longer available on the LCCG 2012 menu. Other studies that have analysed

NMES content have reported a significant reduction in NMES since the introduction of the GNBS (SFT, 2008, SFT, 2009).

6.4 Aim 3: The impact of a mid-morning snack on cognition

Aim 3, was to investigate the impact that a mid-morning snack may have on cognitive function, particularly concentration and memory. It has been suggested that nutrition provision in schools can promote additional educational benefits in terms of readiness to learn, attention, behaviour, concentration. Previous research has suggested that even when an adequate diet of macronutrients and micronutrients is consumed, short term hunger may still affect cognitive function, behaviour, concentration and attention (Benton, 2001).

The majority of studies investigating the effect of food intake on cognitive function in children have focused on the effects of breakfast consumption (Wesnes *et al,* 2003, Mahoney *et al*, 2005). Studies by Muthayya *et al*, 2007 and Wesnes *et al*, 2003, suggested that children's cognitive performance declines mid-morning, therefore it may be possible that if a benefit of energy intake is demonstrable for breakfast, then the same reasoning may apply to a mid-morning snack. For that reason, this current study investigated the relationship between the provision of a mid-morning snack and cognitive function, and particularly memory function.

The current study demonstrated a significant difference in results between cognitive tests which were performed on two occasions at mid-morning break with a snack and without a snack; these results suggest that a mid-morning snack can improve memory in children aged 6-7 years old. There was a considerable improvement in the memory function of children between test one and test two. The method used in this current study to assess cognitive function (concentration and memory) was a version of Kim's game, in which children were asked to memorise and recall pictures. These results are consistent with previous findings by Muthayya *et al*, 2007, Benton & Jarvis, 2007, and Busch *et al*, 2002, that reported that children's attention was better following a snack than a placebo; however most studies have reported mixed findings. Muthayya *et al* 2007, found that snack consumption had an effect on memory but not on sustained attention, however Busch *et al*, 2002 reported the opposite findings, that a snack had an effect on sustained attention and not on memory.

The current study utilised the provision of a free piece of fruit which is supplied by the 'School fruit and vegetable scheme. The (NSFS) was introduced in 2001 by the Department of Health (DH), with the aim to provide two million school children aged 4-6 years with free snack of fruit or vegetable on each school day (NSFS, 2000). On the days of testing all children were supplied with a red apple, some studies which have investigated the relationship between nutrition and cognitive function, have demonstrated that different food types may have more of an effect than others. The results from the current study support the suggestion that a carbohydrate based snack raises blood glucose, which in turn facilitates cognitive function and particularly memory (Benton *et al*, 2003).

6.5 The limitations and strengths of this study

Any measurement of nutrients is problematic and subject to errors, indirect nutrient databases have limitations, for example, the variability in food composition, the incomplete coverage of all foods on the menu and also that portion size needs to be estimated (Greenfield, 2003). Wherever possible variations were reduced, for example, meals weights had been recorded during sample collection, therefore they could be used as a guide for the food database, and where possible each menu item was matched as closely as possible to the foods listed in the database. However, indirect nutrient databases cannot take into account the variability in food composition which is based on a variety of factors. For example, the nutrient content of both plant and animal foods depends on their variety or breed and the conditions in which they were grown, raised and stored (Pawlizyn, 2002).

Laboratory based analyses is suitable for the analysis of virtually any type of food sample, and is not subject to the same restrictions as indirect nutrient database analysis. However, laboratory based analyses can be subject to trace contamination, this was avoided as much as possible by care in handling samples, and also multiple testing for repeatability. However, this study encountered probable contamination which meant that the laboratory analyses of iron could not be reported.

Another limitation of our laboratory analysis is that we measured total fat rather than dietary fat. Dietary fat is composed of saturated fatty acids and essential fatty acids, which can be further subdivided into a more detailed analysis of the lipid composition of the diet, would have been interesting because there has been much concern regarding the levels of saturated fatty acids in our children diets (Popkin & Gordon-Larsen, 2004).

One of the strengths of this study is that it uses two types of analyses, laboratory analyses and indirect WND analysis, which allowed the comparison of both findings.

Most other nutritional studies rely on indirect nutrient database analysis rather than laboratory analysis (Weber & Morais, 2010).

Interpretations of analyses based on mean results can be potentially misleading, since there can be variations between nutrients per meal. A child can potentially choose the unhealthiest choice everyday; therefore there is no guarantee of meeting recommended standards unless each meal choice is nutritionally equal. However this study did demonstrate a daily mean total, which is more descriptive than a mean total for the whole of the menu.

Some studies have analysed meals from more than one school, whereas this study only used one (Gougeon *et al*, 2011), which limits the measure of variability between school meals. Though the same prepared menu is supplied to different schools in Lancashire by LCCG, each school may re-heat, store or even serve the food differently which would effect the nutrient content of each school meal consumed. This would mean that one school is not necessarily representative of all schools in Lancashire. Secondly, this study achieved a daily average nutrient content per meal, by merging the three daily menu choices supplied. This may not necessarily reflect the differences in portion size and wastage etcetera, as studies have shown that there may be significant variability in meal portion sizes being served in our schools, and that this will have an effect on the nutrient intake of children (Howell *et al*, 2008). However, one of the strengths of this study is that the whole of the three week menu was analysed, a total of 45 meals, whereas other studies have only tested one day or one lunch (Rees *et al*, 2008, Gougeon *et al*, 2011).

For practical reasons, the current study was limited to selected nutrients; therefore not all of the GNBS recommendations for nutrients could be tested, this would be recommended for further research.

When undertaking research on any single person or a collection of people, the testing or reactive effect could have occurred, threatening internal validity (Campbell & Stanley, 1963). This means that the participation in this study could have influenced the meal service, meaning that what was collected may not be a true reflection of their daily meal. In order to prevent this threat to internal validity, samples where extracted randomly from a selection of meals which had been pre-served for children to collect.

The third aim of the current study, to test the impact of a mid-morning snack on cognitive performance, could also be subject to the testing effect, because it was a within subjects design. The testing effect can occur when the pre-test itself can influence the post-test, simply because the participant has more experience with the test, this is known as the practice effect. However the practice effect can be reduced by using a slightly different form of the test at post-test (Campbell & Stanley, 1963). Therefore to reduce this effect as much as possible whilst still repeating the same test twice, on the second test the same number of pictures were shown for the same amount of time, but the pictures where changed so the children did not remember the pictures from the first test.

Another limitation of the cognitive tests undertaken to assess the impact of a mid-morning snack on cognitive performance was that children were tested in groups, because of the limited time available. Ideally, it would have been beneficial to test children individually to avoid any possible influences or disruptions from other children in the test group. However, in order to reduce the effect of influences and disruptions as much as possible, children were seated equally, a suitable distance away from each other, in a quiet classroom area whilst they were tested.

Though the findings from this cognitive study reveal a significant improvement in short term memory following a mid-morning snack, it is necessary that we are cautious about the findings. Firstly, the Kim's Game is not a validated short term memory test, and secondly the sample size was limited. The tool used to evaluate short term memory was an age modified version of Kim's Game, a Visual memory test (www.**educationscotland**.**gov**.**uk**/studyskills/**kimsgame**/index.asp). This test has been used to measure memory in schools and scout groups over many years, after talking to teachers this memory game was suggested to be suitable for the age of the children being tested, and also the sample size and time limitations. This memory test was first described in Rudyard Kipling's novel 'KIM' 1901 (Kipling, 1901).

CHAPTER 7

CONCLUSION AND RECOMENDATIONS

This chapter summarises and concludes the main findings from the research undertaken and suggests recommendations for improvement in school nutrition provision.

7.1 Conclusion

In conclusion, the school meals as were provided to primary school children in Lancashire by the LCCG, generally met the GNBS for total fat, protein and in part calcium. However, carbohydrate content was below the recommended GNBS; however this may be due to a reduction in NMES. Total energy was significantly below the recommended GNBS, both of the analyses revealed that on average the school meals provided 25% less energy than recommended. Research suggests that this may be due to smaller portion sizes, Howell *et al*, 2008, however, other studies have observed that school meal energy consumption is significantly lower than the recommended school meal energy provision (SFT, 2009a), reporting that school meal energy consumption is more in line with LCCG provision. This would suggest that for the average primary aged child, a smaller portion size would be more appropriate, and furthermore in light of the increase in childhood obesity a lower energy intake would not be unwelcome. Regarding LCCG school meals as provided at the lower energy content, sodium values were only slightly higher than the maximum GNBS, however these values increased significantly when converted into mg/kcal, indicating that sodium content needs addressing to avoid future health problems.

Primary school meals have improved since 2002 with regard to fat and protein, whereas levels for energy kcal and CHO have decreased and did not meet the minimum GNBS. The lower energy content may be due to a reduction in total fat and although not analysed NMES, as discussed earlier pg 100. The calcium content of school meals have decreased since 2002, however calcium findings generally met GNBS. Sodium levels have improved, however they are still need to be reduced.

The results from the current study suggest that a mid-morning snack can improve cognitive function, 'particularly memory' in children aged 6-7 years old. The cognitive tests were performed at mid-morning break with a snack and without a snack. Results showed that there was a considerable improvement in the memory function of children between test one and test two. These findings are similar to previous studies which have found significant effects of a snack on cognitive function, (Muthayya *et al* 2007). The current study supports the findings of Muthayya *et al*, 2007, that a mid-morning snack can improve memory in children, as there was a considerable improvement in the memory function of children between test one without a snack and test two with a snack.

7.2 Recommendations

It would be recommended from these findings that the protein, sodium and iron content of the LCCG school meals needs to be addressed. Excessive protein intakes are of no benefit to young children and could be linked to certain health risks suggesting further investigation is needed. However, it would be recommended that the LCCG school menu pay further attention to the vegetarian diet, as most of the protein options were from dairy products, and ideally protein intake should come from more than one source to achieve a good balance of essential amino acids. Although the analysis of both the 2012 and 2002 LCCG menus has shown significant improvement in the sodium content of LCCG school meals, it is imperative that the current sodium content of LCCG primary school meals is lowered further and brought more inline with the GNBS. With regard to iron, because GNBS require red meat to only be offered on the menu twice per week, it is necessary that greater attention is given to offering more iron rich options on the menu, as suggested pg 94, with attention also being taken regarding vegetarian diets.

It may be that the smaller school meal portions are suitable for the majority of primary school children; however to compensate for the energy deficit at lunchtime, more healthy complex CHO based snacks should be provided both mid-morning and mid-afternoon. This would both, help to meet the nutrient needs of growing children (Duggan *et al*, 2008), and would also be beneficial to education by reducing a decline in cognitive function due to short term hunger and therefore improving cognitive performance.

7.3 Future expansion of this study

Further research needs to be conducted to investigate children's food consumption. This study has investigated the nutritional quality of the school meals being served, however the wastage of the school meals was not taken into consideration. The wastage, 'what children leave on the plate' needs to be recorded to assess children's nutritional intake. Also assessment of portion size, 'a measurement of each meal served' would also help us understand further, children's school meal nutritional intake.

As mentioned in the limitations of this study, one primary school was assessed as a representation of all schools receiving the same nutritional provision from LCCG. However all schools could have slightly different preparation methods, which in effect could change the nutritional quality of the schools meals being served.

Further research should take into account school meals being served in more than one school, this would allow for differences that might occur in the storing, heating and serving of the school meals, which could potentially effect nutritional quality of the meals served. Furthermore, this current study analysed the whole three week LCCG menu by merging the three daily menu choices supplied to reduce the sample numbers. Ideally a smaller collection of samples could be collected from more than one school in Lancashire, a smaller sample collection could allow for a more specific analysis of nutrient content and also portion size.

The effect of nutrition on cognitive function is an ever expanding area of research; this study demonstrated a snapshot of its potential. It would be valuable for educators to understand how different diets and different nutrients ‘certain minerals such as iodine, zinc and iron, influence behaviour and cognitive function both long and short term. More research is needed into both the type and timing of nutrients on cognitive function, and the overall diet on cognitive function.

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One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Lab energy compared GNBS	15	391.6667	71.54486	18.47280

One-Sample Test

	Test Value = 530					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lab energy compared GNBS	-7.488	14	.000	-138.33333	-177.9536	-98.7131

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets energy compared GNBS	15	410.5453	44.35138	11.45148

One-Sample Test

	Test Value = 530					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets energy compared GNBS	-10.431	14	.000	-119.45467	-144.0156	-94.8937

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Lab fat compared GNBS	15	8.2800	2.06729	.53377

One-Sample Test

	Test Value = 20.6					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lab total fat compared GNBS	-23.081	14	.000	-12.32000	-13.4648	-11.1752

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets total fat compared GNBS	15	15.7833	3.46565	.89483

One-Sample Test

	Test Value = 20.6					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets total fat compared GNBS	-5.383	14	.000	-4.81667	-6.7359	-2.8975

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
lab CHO compared GNBS	15	52.6560	12.21611	3.15419

One-Sample Test

	Test Value = 70.60					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
lab CHO compared GNBS	-5.689	14	.000	-17.94400	-24.7091	-11.1789

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets CHO compared GNBS	15	53.6707	7.48592	1.93286

One-Sample Test

	Test Value = 70.60					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets CHO compared GNBS	-8.759	14	.000	-16.92933	-21.0749	-12.7838

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Lab Protein compared GNBS	15	13.2100	2.91004	.75137

One-Sample Test

	Test Value = 7.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lab Protein compared GNBS	7.599	14	.000	5.71000	4.0985	7.3215

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets Protein compared GNBS	15	16.2987	3.27328	.84516

One-Sample Test

	Test Value = 7.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets Protein compared GNBS	10.411	14	.000	8.79867	6.9860	10.6114

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Lab sodium compared GNBS	15	499.7667	178.94376	46.20308

One-Sample Test

	Test Value = 499					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lab sodium compared GNBS	.017	14	.987	.76667	-98.3291	99.8624

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets sodium compared GNBS	15	515.8467	160.18387	41.35930

One-Sample Test

	Test Value = 499					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets sodium compared GNBS	.407	14	.690	16.84667	-71.8602	105.5535

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Lab Calcium compare GNBS	15	209.9313	81.47910	21.03781

One-Sample Test

	Test Value = 193					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lab Calcium compared GNBS	.805	14	.434	16.93133	-28.1903	62.0530

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets Calcium compared GNBS	15	171.2667	45.68805	11.79660

One-Sample Test

	Test Value = 193					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets Calcium compared GNBS	-1.842	14	.087	-21.73333	-47.0345	3.5679

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Energy	WD	15	410.5453	44.35138	11.45148
	LAB	15	391.6667	71.54486	18.47280

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Energy	Equal variances assumed	.987	.329	.869	28	.392	18.87867	21.73432	-25.64207	63.39941
	Equal variances not assumed			.869	23.376	.394	18.87867	21.73432	-26.04227	63.79960

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Fat	WD	15	15.7833	3.46565	.89483
	LAB	15	8.2800	2.06729	.53377

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Fat	Equal variances assumed	4.070	.053	7.201	28	.000	7.50333	1.04193	5.36903	9.63764
	Equal variances not assumed			7.201	22.843	.000	7.50333	1.04193	5.34711	9.65956

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
CHO	WD	15	53.6707	7.48592	1.93286
	LAB	15	52.6560	12.21611	3.15419

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
CHO	Equal variances assumed	.382	.542	.274	28	.786	1.01467	3.69930	-6.56301	8.59234
	Equal variances not assumed			.274	23.215	.786	1.01467	3.69930	-6.63400	8.66334

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Protein	WD	15	16.2987	3.27328	.84516
	LAB	15	13.2100	2.91004	.75137

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Protein	Equal variances assumed	.396	.534	2.731	28	.011	3.08867	1.13086	.77220	5.40513
	Equal variances not assumed			2.731	27.621	.011	3.08867	1.13086	.77077	5.40656

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Sodium	WD	15	515.8467	160.18387	41.35930
	LAB	14	505.2879	184.36808	49.27444

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Sodium	Equal variances assumed	.019	.893	.165	27	.870	10.55881	64.01104	-120.78099	141.89861
	Equal variances not assumed			.164	25.854	.871	10.55881	64.33166	-121.71312	142.83074

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
CALCIUM	WD	15	171.2667	45.68805	11.79660
	LAB	15	209.9313	81.47910	21.03781

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
CALCIUM	Equal variances assumed	4.862	.036	-1.603	28	.120	-38.66467	24.11948	-88.07119	10.74186
	Equal variances not assumed			-1.603	22.012	.123	-38.66467	24.11948	-88.68386	11.35453

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets energy 2012 GNBS	15	410.5453	44.35138	11.45148

One-Sample Test

	Test Value = 530					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets energy 2012 GNBS	-10.431	14	.000	-119.45467	-144.0156	-94.8937

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Windiets energy 2002 GNBS	15	566.6313	134.19028	34.64778

One-Sample Test

	Test Value = 530					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Windiets energy 2002 GNBS	1.057	14	.308	36.63133	-37.6808	110.9434

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Fat Windiets 2012 GNBS	15	15.7833	3.46565	.89483

One-Sample Test

	Test Value = 20.60					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fat Windiets 2012 GNBS	-5.383	14	.000	-4.81667	-6.7359	-2.8975

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Fat Windiets 2002 GNBS	15	24.5873	7.15717	1.84797

One-Sample Test

	Test Value = 20.60					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fat Windiets 2002 GNBS	2.158	14	.049	3.98733	.0238	7.9508

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CHO WinDiets 2012 GNBS	15	53.8040	7.62439	1.96861

One-Sample Test

	Test Value = 70.60					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
CHO WinDiets 2012 GNBS	-8.532	14	.000	-16.79600	-21.0182	-12.5738

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CHO Windiets 2002 GNBS	15	72.7347	21.87548	5.64823

One-Sample Test

	Test Value = 70.60					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
CHO WinDiets 2002 GNBS	.378	14	.711	2.13467	-9.9796	14.2489

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Protein Windiets 2012 GNBS	15	16.3007	3.27240	.84493

One-Sample Test

	Test Value = 7.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Protein Windiets 2012 GNBS	10.416	14	.000	8.80067	6.9885	10.6129

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Protein Windiets 2002 GNBS	15	18.6507	3.75159	.96866

One-Sample Test

	Test Value = 7.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Protein Windiets 2002 GNBS	11.511	14	.000	11.15067	9.0731	13.2282

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Sodium WinDiets 2012 GNBS	15	515.8467	160.18387	41.35930

One-Sample Test

	Test Value = 499					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Sodium Windiets 2012 GNBS	.407	14	.690	16.84667	-71.8602	105.5535

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Sodium Windiets 2002 GNBS	15	757.6727	268.44127	69.31124

One-Sample Test

	Test Value = 499					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Sodium Windiets 2002 GBNS	3.732	14	.002	258.67267	110.0148	407.3305

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Calcium Windiets 2012 GNBS	15	172.4400	46.74742	12.07013

One-Sample Test

	Test Value = 193					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Calcium Windiets 2012 GNBS	-1.703	14	.111	-20.56000	-46.4479	5.3279

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Sodium Windiets 2002 GNBS	15	207.8593	67.19970	17.35089

One-Sample Test

	Test Value = 193					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Sodium Windiets 2002 GNBS	.856	14	.406	14.85933	-22.3546	52.0733

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
ENERGY	WD 2012	15	405.0747	46.09946	11.90283
	WD 2002	15	566.6313	134.19028	34.64778

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
ENERGY	Equal variances assumed	8.728	.006	-4.410	28	.000	-161.55667	36.63531	-236.60070	-86.51263
	Equal variances not assumed			-4.410	17.259	.000	-161.55667	36.63531	-238.76212	-84.35122

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Fat	WD 2012	15	15.7833	3.46565	.89483
	WD 2002	15	24.5873	7.15717	1.84797

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Fat	Equal variances assumed	5.918	.022	-4.288	28	.000	-8.80400	2.05322	-13.00984	-4.59816
	Equal variances not assumed			-4.288	20.223	.000	-8.80400	2.05322	-13.08392	-4.52408

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
CHO	WD 2012	15	53.8040	7.62439	1.96861
	WD 2002	15	72.7347	21.87548	5.64823

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
CHO	Equal variances assumed	8.917	.006	-3.165	28	.004	-18.93067	5.98146	-31.18313	-6.67820
	Equal variances not assumed			-3.165	17.352	.006	-18.93067	5.98146	-31.53098	-6.33036

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Protein	WD 2012	15	16.3007	3.27240	.84493
	WD 2002	15	18.6507	3.75159	.96866

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Protein	Equal variances assumed	.354	.557	-1.828	28	.078	-2.35000	1.28538	-4.98298	.28298
	Equal variances not assumed			-1.828	27.493	.078	-2.35000	1.28538	-4.98517	.28517

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Sodium	WD 2012	15	515.8467	160.18387	41.35930
	WD 2002	15	757.6727	268.44127	69.31124

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Sodium	Equal variances assumed	9.545	.004	-2.996	28	.006	-241.82600	80.71331	-407.15973	-76.49227
	Equal variances not assumed			-2.996	22.848	.006	-241.82600	80.71331	-408.85562	-74.79638

Group Statistics

	Type	N	Mean	Std. Deviation	Std. Error Mean
Calcium	WD 2012	15	172.4400	46.74742	12.07013
	WD 2002	15	207.8593	67.19970	17.35089

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Calcium	Equal variances assumed	2.485	.126	-1.676	28	.105	-35.41933	21.13626	-78.71499	7.87633
	Equal variances not assumed			-1.676	24.979	.106	-35.41933	21.13626	-78.95214	8.11347

N Par Tests

Descriptive Statistics

Cognitive Tests	N	Percentiles		
		25th	50th (Median)	75th
TESTPRESNACK	21	4.0000	7.0000	7.0000
TESTPOSTSNACK	21	7.5000	9.0000	10.0000

Wilcoxen Signed Ranks Test

Ranks

Cognitive Tests		N	Mean Rank	Sum of Ranks
TESTPOSTSNACK - TESTPRESNACK	Negative Ranks	0[a]	.00	.00
	Positive Ranks	19[b]	10.00	190.00
	Ties	2[c]		
	Total	21		

a. TESTPOSTSNACK < TESTPRESNACK

b. TESTPOSTSNACK > TESTPRESNACK

c. TESTPOSTSNACK = TESTPRESNACK

Test Statistics[a]

Cognitive Tests	TESTPOSTSNACK - TESTPRESNACK
Z	-3.834[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Moss Side Primary School
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PR26 7ST
Telephone: 01772 432048
Fax 01772 452540
Headteacher Mrs J M Burdin

Having read the research summary "An assessment of the changes in primary school nutrition since 2006", I am happy that my school is involved in the project and will be very interested in reading the final analysis.

Janet M Burdin

Headteacher.

PARENT INFORMATION SHEET

Project Title: An assessment of the Changes in primary school nutrition since 2006.

Name of Student Researcher: Mrs Christina Seddon, 25/10/12

Supervisor: Dr Nicola Lowe

'Your child is being invited to take part in a research study. Before you decide whether or not to opt out, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully, and ask if there is anything that is not clear, or if you would like more information.

What is the purpose of this study?

This study is being undertaken as part of a Masters by Research Qualification. Nutrition plays an important role in human growth and development throughout life. In the UK, primary school children consume approximately one-third of their daily food intake at lunch time, which is provided either by school or as a packed lunch brought from home. School food has been provided to pupils in England for many decades, however despite the National Nutritional Standards, there has been continued concern over the quality of school nutrition. Several studies have investigated the relationship between primary school nutrition, and its contribution to children' short and long term health and also school achievement.
Therefore the aims of this study are to determine whether nutrition provision in primary schools has improved since 2006, and secondly to investigate the impact of a mid-morning snack on a child's concentration and memory. It is hypothesised that the nutritional Quality of food provided at school has improved since Government Legislation 2006, and secondly that a snack provided mid-morning improves cognitive function in primary school children.

Who is eligible

The eligibility criterion includes year 2 infant children (aged 6-7) who are attending Moss Side Primary School, 2012 – 2013. Exclusion criteria would be children who are not present for both days of testing.

Study Design & What will be involved

Children in year 2 infants (aged 6-7) will be tested for short term memory, with an immediate picture recognition game (cognitive function test); this type of memory game is already used regularly at Moss side primary school (often called "Kims game") and involves, for example, children looking at a tray of objects for a set period of time, then the objects are covered and the children are asked how many they can remember. For the purposes of this research, pictures will be used instead of objects. In test 1, the children will play the memory game post mid-morning break time **before** their fruit snack, and they will be given their fruit snack after test. In test 2, the game will be repeated (on a different day) **after** mid-morning break time having consumed their fruit snack. Each test will take approximately 20 minutes.

Benefits

There are no direct benefits to be gained by taking part in this study, but it is hoped that the information gained may be of assistance to future research, with regards to Primary school nutrition and its contribution to children's short and long term health and also educational achievement in the future.

Do I have to take part & Withdrawal from the Study?

The study is entirely voluntary. Your child(ren) does not need to take part and you are free to withdraw their child(ren) from the study at any time. You will also be able to withdraw any collected data up until final analysis has been undertaken. Please note that if your child is not involved in the testing, alternative teaching arrangements will be made.

Data Handling & Confidentiality

The recorded data gained from this study will be kept anonymous. In order to achieve this anonymity, all children recruited onto this study will be allocated an identification (ID) number which will be used in place of your name in my report. Only the researcher's and supervisors will be able to link the volunteers name to the ID number. Results will be used solely for the researcher's Masters by Research study.

Ethical Consent

Ethical consent has been assessed and approved by UCLAN Ethics Committees

Further Information

It is up to you whether to allow your child to take part in this study. If you would like your child(ren) to be involved, please return the attached consent form to your school within one week of receiving this information sheet. If you have any complaints or concerns about the study, you should contact the project supervisor or head of school.

Researcher: Christina Seddon
Email: CSeddon@uclan.ac.uk

Supervisor: Dr Nicola Lowe
School of Sport, Tourism and the Outdoors
Darwin Building
Room DB106
Tel No: 01772 893519
Email: NMLowe@uclan.ac.uk

‘Thank you for considering taking part in this study and taking the time to read this sheet’.

PARTICIPANT CONSENT FORM

<u>Title of Project:</u> **An assessment of the Changes in primary school nutrition since 2006.**

Your child is being invited to take part in a research study. Children in year 2 infants (aged 6-7) will be tested for short term memory, with an immediate picture recognition game. This game will take 20 min's, on two separate days.

<u>Name of Student Researcher</u>: Mrs Christina Seddon

<u>Supervisor:</u> Dr Nicola Lowe

****Please initial boxes to indicate agreement.***

I have read and understand the participant information sheet dated 25/10/12/version no 1)....... ☐

I have had an opportunity to ask questions and received satisfactory answers............................ ☐

I understand that my child (ren) can be withdrawn from the study at any time, and that data can be removed up until final analysis being undertaken.. ☐

I understand that my child (ren)'s anonymized data will be used for this study........................ ☐

I agree that my child (ren) can take part in the study.

_________________________	__________	___________________
Name of child (ren)	Date	Signature- Parent/Guardian
_________________________	__________	___________________
Researcher	Date	Signature