The knowledge, attitudes and practices regarding food fortification among mill managers and the contribution of maize meal to the micronutrient intake of a national sample of South African adults

by
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Thesis presented in partial fulfilment of the requirements for the degree Master of Nutrition at the University of Stellenbosch

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DECLARATION

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ABSTRACT

The knowledge, attitudes and practices regarding food fortification among mill managers and the contribution of maize meal to the micronutrient intake of a national sample of South African adults

Aim: The aim of this study was to determine the knowledge, attitudes and practices regarding food fortification among maize meal and wheat flour mill managers and to determine the contribution of maize meal to the micronutrient intake of a national sample of South African adults.

Methods: Staff members overseeing fortification at mills in South Africa were recruited for participation. Data were collected by means of a self-administered questionnaire distributed to 211 participants via email, post and fax.

Secondly, South African adults who reported consuming maize meal (n = 2 344) as part of a national consumer survey, were included in the secondary analysis of data. Data were collected by means of a short quantified food frequency questionnaire focussing on maize. Nutrient intakes of participants who consumed maize meal were determined using the South African Food Composition Database and compared to the Dietary Reference Intakes.

Results: Thirty maize meal and wheat flour mill staff (14.2%) completed the questionnaire. More than half (n = 16; 53.3%) of the participants knew when food fortification became mandatory. Only 43.3% of the mills tested the final product at the mill to ascertain if it was fortified. Only 58.3% (n = 14) of the mills obtained their fortification premixes from suppliers that were registered with the Department of Health. The overall knowledge score of mill staff was average (52.2%).

The secondary analysis of data showed that the average portion of cooked maize meal consumed per day (n = 2 344) was 585 g (SD = 543 g) and contributed the following: riboflavin (20%), vitamin A (25%), zinc (34%), vitamin B_6 (45%), niacin (46%), thiamin (57%), folate (67%) and iron (72%) of the Estimated Average Requirements (EAR). Hundred percent of the EAR was met for iron, thiamin and folate for 773 (33.0%), 483 (20.6%) and 621 (26.5%) of the maize meal consumers respectively. The average portion size of maize meal consumed by the unemployed (696 g) were significantly ($p<0.001$) higher than the employed (564 g) consumers. As a result of the higher portion size, all the micronutrients which form part of the fortification programme was significantly ($p<0.001$) higher for the unemployed. Vitamin A, thiamin, riboflavin, niacin, vitamin B_6, folate, iron and zinc intakes were significantly lower for consumers from households earning above R6 000 compared to consumers of maize meal earning below the poverty line (R2 000).

Conclusions:

About half of the participants correctly answered the knowledge questions on food fortification. Despite this, there were shortcomings regarding practices amongst staff overseeing food fortification at the mills. Areas of food fortification practices at the mill level could possibly be improved, making use of results from this study.

In the second study maize meal was shown to be a significant contributor in the diets of the participants. Unemployed and lower household income groups consumed more maize meal in terms of portion size and micronutrient contribution. The results underline the important contribution that the food fortification programme could potentially make to micronutrient intake through the consumption of fortified maize meal.

OPSOMMING

Die kennis, houding en praktyke ten opsigte van voedselverryking onder meul bestuurders en die bydrae van mieliemeel tot die mikronutrient inname van 'n nasionale monster van Suid-Afrikaanse volwassenes

Doelwit: Die doelwit van die studie was om die kennis, houding en praktyke van meul personeel ten opsigte van voedselverryking van mieliemeel en koringmeel vas te stel asook om die bydrae van mieliemeel tot die mikronutriëntinname van 'n nasionale monster van Suid-Afrikaanse volwassenes te bepaal.

Metodes: Personeel verantwoordelik vir die toesighouding oor verryking by meule in Suid-Afrika was gewerf vir deelname. Data is ingesamel deur middel van 'n self-geadministreerde vraelys wat versprei is na 211 deelnemers via e-pos, pos of faks.

Tweedens was inligting van Suid-Afrikaanse volwassenes wat aangedui het dat hulle mieliemeel eet (n = 2 344), as deel van 'n nasionale verbruikers opname, ingesluit in die sekondêre analise. Data is ingesamel deur middel van 'n kort gekwantifiseerde voedselfrekwensie vraelys wat fokus op mieliemeel. Die nutriëntinname van deelnemers wat mieliemeel ingeneem het, is bepaal met die Suid-Afrikaanse Voedselsamestellings Databasis en vergelyk met die Aanbevole Dieetverwysings Innames.

Resultate: Dertig personeellede van mieliemeel en koringmeel meule het die vraelys voltooi (14.2%). Meer as helfte (n = 16; 53.3%) van die deelnemers het geweet wanneer voedselverryking verpligtend geword het. Slegs 43.3% van die meule toets die finale produk by die meul om vas te stel of dit verryk is. Slegs 58.3% (n = 14) van die meule het hul verrykingsmengsel van verskaffers, wat geregistreer is by die Departement van Gesondheid verkry. Die algehele kennis puntetelling van meul personeel was gemiddeld (52.2%).

Die resultate van die sekondêre analise van die mieliemeel inname data het getoon dat die gemiddelde porsie gekookte mieliemeel vir die groep 585 g (SD = 543 g) per dag was, en het die volgende bydrae gelewer: riboflavien (20%), vitamien A (25%), sink (34%), vitamien B_6 (45%), niasien (46%), tiamien (57%), folaat (67%) en yster (72%) van die Geskatte Gemiddelde Behoeftes (GGB). Honderd persent van die GGB vir yster, tiamien en folaat is deur 773 (33.0%), 483 (20.6%) en 621 (26.5%) van die mieliemeel verbruikers onderskeidelik, ingeneem.

Die gemiddelde porsie mieliemeel (696 g) ingeneem deur werklose verbruikers was aansienlik ($p<0.001$) groter as die porsie (564 g) deur werkende mieliemeel verbruikers. Al die mikronutriënte wat deel van die voedselfortifiseringsprogram is, was gevolglik aansienlik ($p<0.001$) hoër vir die werklose verbruikersgroep weens die groter porsie. Vitamien A, tiamien, riboflavien, niasien, vitamien B_6, folaat, yster en sink inname was aansienlik laer vir verbruikers van huishoudings wat bo R6 000 verdien in vergelyking met verbruikers van mieliemeel wat onder die broodlyn (R2 000) verdien.

Gevolgtrekkings: Omtrent helfte van die deelnemers het die kennisvrae oor voedselverryking reg beantwoord. Ten spyte daarvan, was daar tekortkominge met die voedsel verrykingspraktyke van personeel by die meule en dit kan moontlik verbeter word deur gebruik te maak van die resultate van die studie.

In die tweede studie is dit bewys dat die bydrae wat mieliemeel in die dieete van die deelnemers gelewer het, aansienlik was. Werklose- en laer huishoudelike inkomste groepe het meer mieliemeel ingeneem in terme van porsie en mikronutriënt bydrae. Die resultate onderstreep die moontlike bydrae wat voedselfortifisering kan maak tot mikronutriënt inname deur die inname van verrykte mieliemeel.

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CONTRIBUTIONS BY PRINCIPAL RESEARCHER AND FELLOW RESEARCHERS

The principal researcher, Natasha Annalise Danster-Christians, developed the idea and the protocol. For Chapter 3, the principal researcher planned the study, undertook data collection, captured the data for analyses, analysed the data with the assistance of the supervisor (Dr Petronella Wolmarans) and statistician (Mrs Ria Laubscher) interpreted the data and drafted the thesis. For Chapter 4, the principal researcher checked the data for secondary analyses, analysed the data with the assistance of the supervisor (Dr Petronella Wolmarans) and statistician (Mrs Ria Laubscher) interpreted the data and drafted the thesis. Dr Petronella Wolmarans, Dr Hester-Mari Burger and Mrs Lynette Daniels (co-supervisors) provided input at all stages and revised the protocol and thesis.

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LIST OF ABBREVIATIONS

AI	Adequate Intake
BRISK	Risk Factor Study in the urban Black population
CORIS	Coronary Risk Factor Study
CRISIC	Coronary Risk Factors in an urban Coloured population
dL	decilitre
DOH	Department of Health
DRI	Dietary Reference Intakes
EAR	Estimated Average Requirement
EC	Eastern Cape
EER	Estimated Energy Requirement
EHP	Environmental Health Practitioners
FAO	Food and Agricultural Organization
FS	Free State
g	grams
GP	Gauteng Province
Hb	haemoglobin
HHI	Household Income
IQR1	Interquartile range
IQR3	Interquartile range
IU	International Units
kg	kilograms
kJ	kilojoules
km	kilometres
KZN	KwaZulu-Natal
LCS	Living Conditions Survey
LP	Limpopo Province
mg	milligram

MI	Micronutrient Initiative
ml	millilitre
MP	Mpumalanga Province
MRC	Medical Research Council
MT	Metric Ton
NC	Northern Cape
NCM	National Chamber of Milling
NFCS	National Food Consumption Survey
NFCS-FB-I	National Food Consumption Survey-Fortification Baseline
ng	nanogram
nmol	nanomole
NTD	Neural Tube Defects
RDA	Recommended Dietary Allowance
RNI	Recommended Nutrient Intakes
SAFOODS	South African Food Data System
SAGIS	South African Grain Information Services
SANHANES	South African National Health and Nutrition Examination Survey
SAVACG	South African Vitamin A Consultative Group
SD	Standard Deviation
SQFFQ	Short Quantified Food Frequency Questionnaire
THUSA	Transition, Health and Urbanisation in South Africa study
µg RE	micrograms Retinol Equivalents
WC	Western Cape
WHO	World Health Organization

LIST OF SYMBOLS

=	equal to
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
X	multiplied by
+	over
%	percentage
R	Rand
-	to

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Chapter 1
GENERAL INTRODUCTION

1.1 Problem statement

It is estimated that more than two billion people worldwide are micronutrient deficient in key vitamins and minerals, particularly vitamin A, iodine, iron and zinc.[1] In 1994, the South African Vitamin A Consultative Group (SAVACG) found that nationally 33% of pre-school children had a marginal vitamin A status (serum retinol concentration <20 µg/dL). Additionally, the prevalence of anaemia was 21% (Hb <11 g/dL) and 1% had a visible goitre.[2] In 1999, the National Food Consumption Survey (NFCS) was conducted to quantify the nutrient intakes and determine the anthropometric status of children (1-9 years old).[3] Nationally 55-68% of children (1-3 years = 55%, 4-6 years = 60%, 7-9 years = 68%) had a vitamin A intake less than half the Recommended Dietary Allowance (RDA) (400, 500, 700 microgram Retinol Equivalents (µg RE) respectively). For iron and zinc, 41-63% and 52-69% respectively, of children had an intake less than 50% of the RDA. For the rest of the micronutrients, nationally the intakes for vitamin B_6 22-30%, riboflavin 28-46%, niacin 25-33%, folate 36-54%, vitamin C 61-63%, vitamin D 87-88% and vitamin E 54-57% of all the age groups (1-3, 4-6, 7-9 years), were less than 50% of the RDA.[3]

The 1999 NFCS identified maize meal and bread as the most commonly consumed staple foods in South Africa.[3] Following extensive feasibility, organoleptic and market based research the Government of South Africa introduced legislation on the mandatory fortification of maize meal and white and brown bread flour in 2003.[4] In 2005, the National Food Consumption Survey Fortification Baseline Survey (NFCS-FB-I) was undertaken to establish a base from which the food fortification policy could be monitored and evaluated in future.[5] The aim of the NFCS-FB-I survey was to describe the anthropometric, iron, iodine, zinc, folate and vitamin A status of children (1-9 years old) and females of reproductive age (16-35 years old) in South Africa. In addition, the knowledge, attitudes and practices of females with regard to food fortification and fortified products was also evaluated.[5] Even though the survey was conducted 14 months after the implementation of the food fortification legislation, the findings of the survey indicated high rates of vitamin A, iron and zinc deficiencies among children and females. The results of the survey can therefore be used as a point of reference in the future monitoring of the mandatory food fortification programme.[5] Approximately sixty three percent of the children (1-9 years old) presented with a serum retinol concentration less than 20 µg/dL and 45.3% were zinc deficient (<65 µg/dL).[5] Comparison of the vitamin A status (<20 µg/dL) of children in the 2005 NFCS-FB-I with the national data obtained from the 1994 SAVACG study, showed an increase in vitamin A deficiencies from 33.3% to 63.6% in children under five years of age.[2,5] When comparing the vitamin A status of children (under five years of age) of the 2005 NFCS-FB-I with the findings of the South African National Health and

Nutrition Examination Survey (SANHANES) conducted in 2012, vitamin A deficiency showed a decrease to 43.6% which still constitutes levels of a deficiency of public health significance.[6] These findings, however, should be interpreted with caution since there are concerns about the validity of national estimates of vitamin A deficiency. These include the limited sample sizes as there was a much smaller sample in the 2005 survey (n = 1 388) compared to the 1994 study (n = 4 283). In addition, the 2012 SANHANES study included a very small sample (n = 436) and due to this the results are not considered representative at national level.[2,5,6]

The slow pace of improvement in the micronutrient status of children and females since inception of the food fortification programme in 2003, observed in the 2005 NFCS-FB-I, prompted an investigation into the status of monitoring and compliance of the South African staple food fortification programme during the period April-June 2010.[7] This investigation entailed conducting interviews with various food fortification stakeholders (government departments, research units, fortification premix suppliers, millers, fortification consultants and analytical laboratories) to ascertain their roles in the food fortification programme, their views on the current state of monitoring and compliance of the programme and practical ways of strengthening the programme.[7] As mentioned in the strengthening monitoring and compliance report, findings revealed that less than 16% of maize meal samples collected from mills in six of the nine South African provinces complied with the regulations. The level of several key micronutrients added to maize meal and white bread flour were unsatisfactory because of insufficient addition of fortification premixes at the mills, however, once this was observed the Government of South Africa undertook specific remedial actions such as the registration of premix suppliers with the Medicines Control Council.[4,7]

The level of fortification (vitamin A, niacin, iron) of maize meal and white bread flour samples at the retail level from all nine provinces was compared with the staple food fortification regulations in South Africa between November 2010 and March 2011. One hundred and sixty (84%) of the maize meal and white bread flour samples tested qualitatively, indicated the presence of iron, nine (5%) contained traces of iron and 22 (12%) samples had no iron detected. For vitamin A, only 9% and 18% met the fortification requirement at manufacturer level for white bread flour (1 786 µg RE per 1 kg flour) and maize meal (2 085 µg RE per 1 kg meal) respectively.[8]

The success of a food fortification programme does not only rest with the policy makers of the Department of Health (DOH). It is imperative that all role-players, including maize meal and white and brown bread flour manufacturers, environmental health practitioners, fortification premix suppliers and the DOH involved in the food fortification programme acquire the relevant knowledge and training to implement the programme effectively. Poor quality fortification of maize meal and white and brown bread flour affects the micronutrient intake of consumers of the fortified products and potentially averts the desired reduction in vitamin and mineral deficiencies expected through the fortification programme.[2]

A national consumer survey independantly conducted in 2011 by a reputable South African leading grain-based manufacturing company provided information on maize intakes of a national sample of adults aged 16-88 years old. The data were collected as part of a study to assess human exposure to mycotoxin in various milling fractions of maize samples.[9,10] Intakes stratified by province indicated a higher maize consumption in the Limpopo, Mpumalanga and KwaZulu-Natal provinces compared to the Free State, Northern Cape, Gauteng and Eastern Cape which had similar intakes, followed by the North West and Western Cape with the lowest intakes. Males consumed on average more maize compared to females.[11] This data provided an opportunity to conduct secondary analysis to assess the micronutrient intakes from fortified maize meal among a nationally representative sample of South Africans.

Current information indicated that the food fortification programme was inadequate as high rates of vitamin A, iron and zinc deficiencies still prevailed.[5,7,8] The findings by consultants, who examined the quality assurance and monitoring system of the food fortification programme, that non-compliance of millers could be caused by a lack of understanding of the requirements of the programme, prompted this study. The study was undertaken with the aim of identifying gaps in the knowledge, attitudes and practices regarding food fortification among mill managers, which could have an impact on the outcome of the fortificant level of the fortified maize meal and white bread flour sold at retail level.

As part of the national consumer survey conducted by the grain-based manufacturing company among end consumers of grain products (maize, rice and flour), a maize-based Short Quantified Food Frequency Questionnaire[12] with portion size photos[13] of maize dishes was added to obtain information on usual maize intakes. The data on maize meal intakes of South Africans collected in the national consumer survey[11] now provided an opportunity to assess the micronutrient intakes from maize meal on a national sample of adults in South Africa.

1.2 Study aims and objectives

The aims of the research study described in this thesis were:

a) To determine the present knowledge, attitudes and practices regarding food fortification among the maize meal and wheat flour mill managers after the food fortification legislation has been in place for more than nine years.

b) To determine the contribution of maize meal to the micronutrient intakes (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc) of a national sample of South Africans.

1.3 Specific objectives

- To gather information on the knowledge, attitudes and practices regarding food fortification among the maize meal and wheat flour mill managers in South Africa.
- To do secondary analysis on a dataset from the 2011 national consumer survey[11] to determine the micronutrient intakes (vitamin A, thiamin, riboflavin, niacin, vitamin B_6, folate, iron and zinc) as derived from the maize meal intakes of a national sample of South Africans using the food composition database in the South African Food Data System (SAFOODS).[14]

- To do secondary analysis on a dataset from the 2011 national consumer survey[11] to determine the energy and macronutrient intakes (total fat, total protein, total available carbohydrate, dietary fibre) as derived from the maize meal intakes of a national sample of South Africans, using the food composition database in SAFOODS.[14]
- To compare, for each individual, the energy, macro-and-micronutrient contribution of fortified maize meal to the Dietary Reference Intakes[15,16,17] for the different age and gender groups.

1.4 Thesis outline

A review of the literature on food fortification, the history and programmes implemented in the various countries as well as an overview of food fortification in South Africa are given in Chapter 2. Chapters 3 and 4 are written in article format. Chapter 3 describes the study to collect questionnaire information on the knowledge, attitudes and practices regarding food fortification among the maize meal and wheat flour mill managers in South Africa. The contribution of maize meal to micronutrient intakes (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc), based on secondary analysis of data from a national sample of South Africans aged 16-88 years old, is described in Chapter 4. Chapter 5 covers a general discussion and summary of the results of the research, concludes the thesis and provides further recommendations.

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Chapter 2
REVIEW OF THE LITERATURE

This review starts by providing an overview of global food fortification practices, followed by the history of food fortification globally and thereafter, a closer look at the South African food fortification context.

Overall micronutrient malnutrition among South African adults and children will be discussed followed by a summary of dietary intake studies conducted in South Africa.

2.1 Food fortification

2.1.1 What is food fortification?

The Codex Alimentarius Commission of the United Nations defines food fortification as the "addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups".[1] The aim with food fortification is to improve the quality of the diet by adding essential nutrients to levels higher than those naturally found in a food. It is an internationally accepted strategy and one of the most cost effective means of improving micronutrient status of populations and nations.[2] Micronutrients are vital for human growth and development, especially in the vulnerable groups such as the elderly, young children and females of reproductive age.[3] Other strategies to prevent and control micronutrient malnutrition include: diet diversification, pharmacological supplementation and public health approaches such as immunisations.[4]

2.1.2 Global food fortification practices

Regarding wheat flour, by April 2015, 81 countries (developed and developing) worldwide adopted a food fortification programme whereby wheat flour is fortified with at least iron or folic acid.[5] The type and quantity of minerals and vitamins added to flour varies in every country, either as voluntary or mandatory requirement. The choice of compound and quantities should therefore be viewed in respect of each country's situation.[6] Australia, however, does not include iron in their programme whereas Congo, Venezuela, the United Kingdom and Philippines exclude folic acid.[5] Figure 2.1 below is a graphic representation of all the countries (shown in red) that apply mandatory wheat flour fortification. Furthermore, there are five additional countries which fortify half of their industrially milled wheat flour through voluntary fortification. These five countries are Gambia, the Democratic Republic of Congo, Namibia, Qatar and the United Arab Emirates.[5]

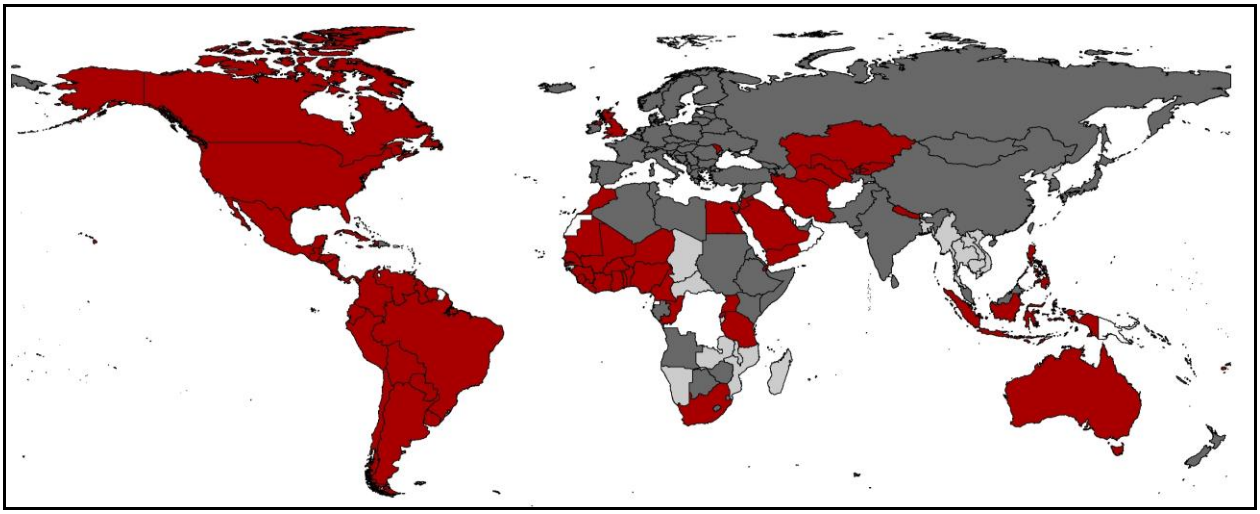

Figure 2.1: Worldwide mandatory wheat flour fortification legislation (indicated in red)[5], (reprinted with permission, Food Fortification Initiative)

Only 12 countries practice mandatory maize meal fortification (Brazil, Costa Rica, El Salvador, Kenya, Mexico, Nigeria, Rwanda, South Africa, United Republic of Tanzania, Uganda, the United States of America and Bolivarian Republic of Venezuela).[5] Figure 2.2 below depicts a graphic representation of all the countries worldwide, indicated in green, which practice mandatory maize meal fortification. Worldwide, there is less experience with fortifying maize flour than wheat flour.[7] Globally the number of countries which practice rice fortification is six whereas 70 countries fortify salt and most of Central and South America practice sugar fortification.[5,8,9]

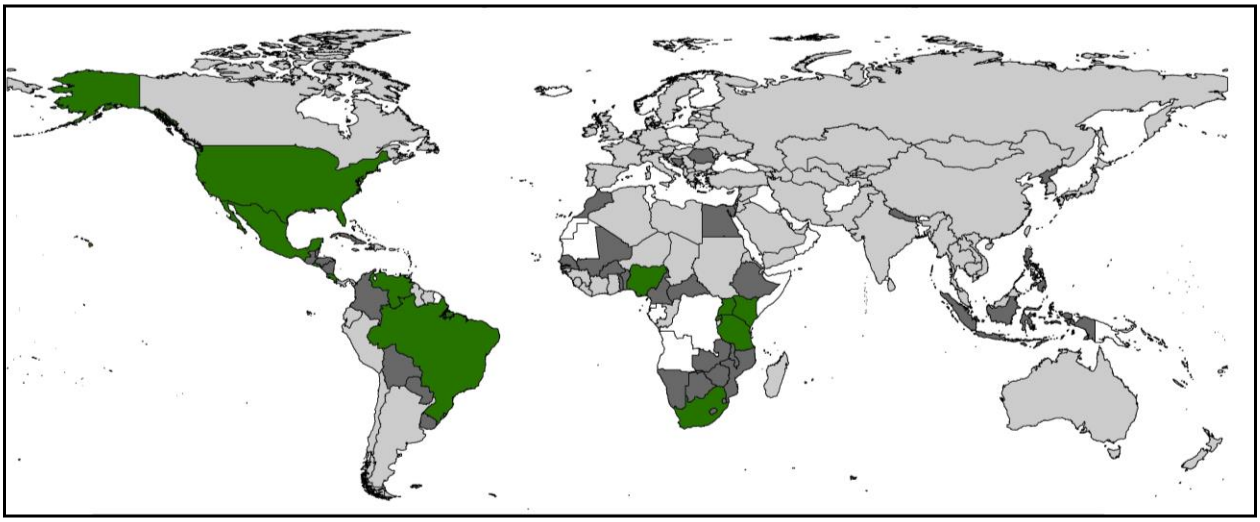

Figure 2.2: Worldwide mandatory maize meal fortification legislation (indicated in green)[5], (reprinted with permission, Food Fortification Initiative)

2.1.3 History of food fortification globally

The introduction of food fortification dates back more than 90 years. In the 20th century food fortification was introduced in the world for the first time.[10] The United States of America (USA) embarked on their long journey with food fortification in the 1920s in the various states to prevent nutritional deficiencies and this necessitated the joint forces of the food industry, the government and the professional health organisations.[11] By 1923, Switzerland implemented the iodisation of table salt to prevent goitre and cretinism.[10] A few years later in 1941, after the initial introduction of flour enrichment, mandatory fortification of flour with vitamin Bs was implemented in the USA. As a result a decline in mortality due to pellagra from 3 000 cases to zero was observed.[10] Thiamine-fortified rice was distributed in the province of Bataan in the Philippines during 1948 and a reduction of deaths caused by beri-beri was identified.[10] Another example of fortification was the vitamin A fortification of sugar introduced in Guatemala in 1974 to prevent blindness and sub-clinical vitamin A deficiency.[10] In the United Kingdom, flour was fortified with vitamin B_1, niacin, folic acid, iron and calcium by 1984.[12]

In the Philippines, the fortification of margarine with vitamin A, called Star brand, was initiated in 1992 by the manufacturer, Procter and Gamble.[13] However, the Philippine Plan of Action for Nutrition was only formulated in 1993 and this resulted in five impact programmes namely food security, micronutrient supplementation and food fortification, credit assistance for livelihood, nutrition education and food assistance. Salt iodisation was implemented in 1995 in the Philippines under the Republic Act No. 8172, the Act for Salt Iodization Nationwide.[14] From 1995 to 1997, wheat flour, sugar and cooking oil were fortified with vitamin A as a component of the food fortification programme of the Philippine Plan of Action for Nutrition.[13]

In 1996 and 1997 the fortification of wheat flour with vitamin B_1 and B_2, niacin, folic acid and iron legislation was passed in Colombia and Ecuador, respectively.[12] January and November 1998 marked the mandatory fortification of cereal grains with folic acid in the USA and Canada respectively.[15] During the pre-fortification period of January 1996 to December 1997, three retrospective studies conducted in Canada among females of reproductive age, elderly females and females who underwent antenatal serum screening found that the mean red blood cell folate concentration increased from 527 to 741 nmol/L[16], serum folate increased by 64% from 14.8 to 24.2 nmol/L[17] and neural tube defects decreased from 1.13 to 0.58 per 1 000 births[18] post food fortification respectively.

The mandatory fortification of maize meal and white and brown bread flour were legislated in South Africa in October 2003. This meant that manufacturers were required by law to fortify with six vitamins (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folic acid) and two minerals (iron, zinc).[19]

2.1.4 Food fortification in Africa

Quite a number of countries have adopted food fortification programmes in Africa of variable coverage and use different iron compounds (as seen in Table 2.1). Zambia, Zimbabwe, Tanzania and Malawi practice small-scale fortification by fortifying maize meal with the multi-micronutrient premixes (including vitamin A) at village hammer mills. This approach was employed since very few individuals had access to centrally produced fortified foods.[20] Even if these local approaches were successful in reducing micronutrient deficiencies, there are still many challenges these countries face, i.e. quality assurance, community mobilisation, training of millers, distribution of the fortification premixes and sustainability.[21]

Table 2.1: Food fortification legislative status for wheat flour and iron compounds used for food fortification in African countries[5]

Fortification status	Country	Iron compound used for food fortification
Mandatory	Benin, Burkina Faso, Cameroon, Congo, Cote d'Ivoire, Ghana, Mali, Mauritania, Niger, Senegal	Ferrous fumurate
	Guinea, Morocco, South Africa	Electrolytic iron
	Kenya, Tanzania, Rwanda, Uganda	NaFeEDTA*
	Egypt	Ferrous sulphate
	Cape, Verde, Liberia, Nigeria, Sierra Leone	Unknown
Voluntary	Gambia	Ferrous fumarate
	Democratic Republic of the Congo	Ferrous sulphate
	Namibia	Unknown
Planning	Botswana, Ethiopia, Lesotho, Malawi, Mozambique	N/A
No fortification	Algeria, Angola, Burundi, Central African Republic, Chad, Comoros, Equatorial Guinea, Eritrea, Gabon, Guinea Bissau, Madagascar, Mauritius, Sao Tome, Seychelles, Somalia, Sudan, Swaziland, Tunisia, Zambia, Zimbabwe	N/A
No information	British Indian Ocean Territory, Libya, Mayotte, Reunion, South Sudan	N/A

*NaFeEDTA = Ferric sodium ethylenediaminetetraacetate

2.1.5 Food fortification in South Africa

2.1.5.1 Voluntary food fortification in South Africa

Voluntary fortification of products such as bread, maize meal and breakfast cereals was practised in South Africa well before 2003. The nutritional status of white (n = 464), black African (n = 585), mixed ancestry (n = 442) and Indian (n = 366) South African school children (7-15 years of age) from the Pretoria area was assessed in 1962, 1963 and 1964.[22] Biochemical assessment of their nutritional status in terms of nicotinic acid was conducted by measuring the urinary excretion levels of two metabolites of nicotinic acid namely 2-pyridone (N^1-methyl-2-pyridone-5-carboxylamide) and N^1-methyl nicotinamide (N^1-Me). These values were then expressed as a ratio (2-pyridone/N^1-Me) with a value of less than one being indicative of nicotinic acid deficiency. Results indicated that a very low percentage (14.1%) of white children in the 7-11 year age category had a ratio below one, whereas in the Indian South African, mixed ancestry and black African children, 24.6%, 32.0% and 53.1% respectively, reflecting a greater number of children suffering from nicotinic acid deficiency. Maize forms the staple diet of the black African population group in South Africa and contains a relatively low content of tryptophan, which is the precursor of nicotinic acid, and as a result explained the high percentage of black African school children who were nicotinic acid deficient.[23]

A study was conducted to test the effectiveness and feasibility of riboflavin and nicotinic acid supplementation in the black African population group subsistent on a maize diet.[24] Maize meal at one particular mill was fortified with a fortification premix containing 3.59 g riboflavin, 35.95 g nicotinamide and 960.45 g of maize meal which was fed into the millstream after obtaining permission from the Maize Board and the actual mill itself. A microfeeder and mixing screws were fitted and the whole production of maize meal was enriched for the experimental group which comprised of 70 children of a nearby primary school, whilst the control group was randomly chosen from a primary school 53 km from the mill and most likely not receiving maize from that mill. Children were evaluated at baseline, at 95 days and 137 days. Enrichment was stopped after the third evaluation and 68 days thereafter the children were evaluated for the fourth time. Nine (13%) children had visible pellagrous lesions at baseline in the experimental group which had disappeared by the second assessment and did not re-appear. The control group had low 2-pyridone/N^1-Me mean ratios at 95 days (0.84) and 137 days (0.78), while for the experimental group the mean ratio exceeded one illustrating how they responded to the enriched maize meal. The urinary riboflavin excretion in the control group remained more or less constant at approximately 300 µg/g creatinine throughout the experiment whereas the excretion of riboflavin in the experimental group was roughly 550 - 600 µg/g creatinine more during the period of enrichment than at baseline. The fortification premix was orange in colour, though after mixing with the maize meal had vanished and the mill manager reported no influence on the sales indicating that maize meal was an appropriate vehicle for fortification.[24]

In 1974, in a study at the Charles Johnson Memorial hospital in KwaZulu-Natal South Africa, the efficacy of a fortified staple food was examined.[25] A synthetic form of folate called pteroylglutamic acid was added to maize meal and the fortified maize meal porridge was given to 38 pregnant females of which 18 females constituted the control group and 20 the supplement or test group. On admission the mean serum folate level for the control and supplement group was 5.2 ng/mL and 4.8 ng/mL, respectively. The mean red cell folate levels were 194 ng/mL for the control group and 199 ng/ml for the test group. The test group exhibited a significant rise in both serum and red cell folate concentrations, while the serum folate levels remained unchanged and red cell folate levels dropped throughout the study in the control group. The fortification of maize meal proved to be effective in this study.[25]

In 1989, a study was conducted by the University of Witwatersrand to analyse the nutrient content of maize meal and to monitor the voluntary fortification of maize meal with riboflavin (2.5 µg/g per 400 g maize meal) and nicotinamide (25 µg/g per 400 g maize meal) in various provinces (Gauteng, Free State, KwaZulu-Natal, Eastern Cape and the former Transkei) in South Africa.[26] Maize meal packets of 2.5 kg samples were purchased from various stores in the different provinces to ensure representation of 31 South African mills. It was found that only three mills had nicotinamide concentrations greater than the recommended level and only two mills had riboflavin concentrations greater than the recommended level, while the rest all had levels below the recommended levels for both nicotinamide and riboflavin. The possible reasons for these low values included detection limitations of analytical methods used, the underestimation of the vitamin content by the techniques used, inadequate mixing of the vitamins into the meal, the instability of the vitamins or insufficient fortification. The study concluded that regular monitoring of the food fortification programmes is required.[26]

2.1.5.2 The South African Vitamin A Consultative Group (SAVACG) study and the National Food Consumption Survey (NFCS)

In 1994, a national survey on 11 430 children, aged 6-71 months, was conducted in South Africa. The main objectives of the study were to establish the vitamin A, iron, zinc, anthropometric and immunisation coverage status of children, focusing on socio-economic status and geographical and age distribution and the degree of urbanisation.[27] Further objectives of the study were to establish the prevalence of visible goitre and breastfeeding practices. The main findings of the study included i) one in three children had a marginal vitamin A status (serum vitamin A concentration <20 µg/dL); ii) nationally one in five children was found to be anaemic; iii) one in 10 children was iron-depleted and one in 20 was severely iron-depleted; iv) iron-deficiency anaemia was found in one of every 20 children and v) one in every 100 children had visible goitre. A recommendation from this survey was that a food fortification programme should be started to address the micronutrient deficiencies in the country.[27]

Recommendations following the South African Vitamin A Consultative Group (SAVACG) study suggested that a National Food Consumption Survey (NFCS) should be conducted in South Africa to collect information on the food consumption patterns of children to formulate policies for food fortification. In 1999, the first NFCS was conducted to determine the nutrient intakes and anthropometric status of children (1-9 years old), as well as factors that influenced their dietary intake.[28] For South African children, the intakes of energy, calcium, iron, zinc, selenium, vitamins A, D, C and E, riboflavin, niacin, vitamin B_6 and folic acid were below two-thirds of the Recommended Dietary Allowance (RDA).[29] Findings from the NFCS identified maize meal, sugar, tea, whole milk and brown bread as the five most commonly eaten foods. A decision was made to use maize meal and flour (bread) as food vehicles for food fortification as these commodities were shown to be the two most commonly consumed staples across South Africa.[30]

2.1.5.3 Preparation for introducing food fortification legislation

In South Africa, the Department of Health (DOH) had a mammoth task to prepare for the implementation of the food fortification regulations by working closely with all the relevant roleplayers such as the milling industry, fortification premix suppliers and environmental health practitioners. In 2002, visits were made by fieldworkers of the University of Pretoria to over 200 millers to ascertain their thoughts and concerns regarding the implementation of food fortification.[31] A questionnaire was distributed to 500 millers and an information guide was compiled addressing micronutrients used in food fortification, quality control, benefits of food fortification, costs involved and frequently asked questions.[31] The findings of this study were considered confidential and the results are not in the public domain.[32]

Following this in 2006, the Micronutrient Initiative (MI), in collaboration with the National Fortification Alliance of South Africa embarked on a survey to identify small and medium sized mills in six of the nine provinces. Millers in only six of the nine provinces in South Africa were targeted to determine their knowledge levels about fortification and compliance with fortification regulations. The findings of this study were used to compile a training manual for millers.[33]

2.1.5.4 Mandatory food fortification in South Africa

Mandatory fortification of the country's main staple foods – maize meal and flour (bread) became effective in October 2003 under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972).[19] This meant that specific vitamins (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate) and minerals (iron, zinc) had to be added to maize meal and white- and brown bread flour. The regulations stipulated that all maize meal and white and brown bread flour milled in South Africa must contain specified amounts of vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc.[19] "The fundamental objective of the staple food fortification programme is to meet the public health objective of providing the South African population with specific quantities of certain essential vitamins and minerals".[34] Electrolytic iron and zinc oxide at a level of 35 mg/kg and 15 mg/kg meal/flour is currently being used by South Africa for its mandatory national food fortification of maize meal and flour.[19] The South African DOH has decided that a new iron compound (NaFeEDTA) will be used as part of the national food fortification programme. The Regulations relating to the fortification of certain foodstuff has been amended to propose 15 mg/kg from NaFeEDTA and the final regulations will be published in 2016.[35] The vitamins currently used for fortification are in the following forms and levels in maize meal and white bread flour per kilogram respectively; vitamin A palmitate (2 085 µg RE and 1 786 µg RE); thiamine mononitrate (2.1875 mg and 1.9444 mg); riboflavin (1.6875 mg and 1.7778 mg); nicotinamide (25.000 mg and 23.6842 mg); pyridoxine hydrogen chloride (3.1250 mg and 2.6316 mg) and folic acid (2.0000 mg and 1.4286 mg).[19] Additionally, these regulations state that any person, who manufactures, imports or sells maize meal or white and brown bread flour, which has not been fortified in accordance with these regulations, shall be guilty of an offence.[19,36] Table 2.2 below depicts a timeline of food fortification milestones in South Africa from 1989 up until 2010.

Table 2.2: A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
1989	Aggett, Van der Westhuyzen, Kuyl, Metz.[26] Monitoring the voluntary fortification of maize meal with riboflavin and nicotinamide	• Retail stores in the Gauteng (former Transvaal), Free State, KwaZulu-Natal, Eastern Cape including the former Transkei	• 57 maize meal packets of 2.5 kg each which were either super or special grade	• Maize meal samples from various provinces were chemically analysed for riboflavin and nicotinamide to monitor voluntary food fortification
1996	Coutsoudis, Hussey, Ijsselmuiden, Labadarios, Harris, Robertson, et al.[27] Anthropometric, vitamin A, iron and immunisation coverage status in children aged 6-71 months in South Africa, 1994	• Children 6-71 months old	• 11 430 children • A national probability sample was drawn with disproportionate stratification by province	• Survey conducted between July and October 1994 on children to establish vitamin A, iron, anthropometric and immunisation coverage status by the South African Vitamin A Consultative Group by means of a national survey
1997	Blum.[37] South Africa ready for mandatory cereal fortification	• N/A*	• N/A*	• National Food Fortification Programme task group was created comprising members from the Department of Health, food industry, academic groups and international bodies such as The United Nations Children's Fund and The Micronutrient Initiative (MI) • Tasks included overseeing the development of the food fortification programme, drafting legislation, initiating training of environmental health practitioners and formulating social marketing ideas for fortified foods

* = Not Applicable

Table 2.2 (contd): A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
1999	Labadarios and Steyn.[29] The National Food Consumption Survey (NFCS): Children aged 1-9 years, South Africa	• Children 1-9 years old	• 2 894 children • 82 urban and 74 non-urban Enumerator Areas (EA) • Households (HH) with at least one child aged between 1 and 9 years old qualified to participate in the survey and only one child from the randomly selected households could partake	• A National Food Consumption Survey conducted to collect information on food consumption patterns and to determine nutrient intakes and anthropometric status
2002	Department of Health.[31] Information for small millers on the national food fortification programme	• Millers of maize meal and wheat flour	• Approximately 200 millers of small-sized mills • An embargo has been placed on the data collected in this study[29]	• Visits made by the University of Pretoria fieldworkers to millers to ascertain their thoughts regarding the implementation of food fortification
2003	Government Gazette.[19] Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972). Regulations relating to the fortification of certain foodstuffs (No.R. 504)	• N/A*	• N/A*	• Food fortification standards enacted April and implemented in October 2003
2005	Labadarios (editor).[38] National Food Consumption Survey-Fortification Baseline (NFCS-FB-I): The knowledge, attitude, behaviour and procurement regarding fortified foods, a measure of hunger and the anthropometric and selected micronutrient status of children aged 1-9 years and women of child bearing age: South Africa, 2005.	• Children 1-9 years old and females of reproductive age (16-35 years old)	• 2 469 children and 2 450 females • 226 EA were included in the survey. HH with at least one child aged between 1-9 years old and at least one female of reproductive age (16-35 years old) formed part of a qualifying EA	• The NFCS-FB-I fieldwork was conducted, which involved collection of anthropometric parameters (height and weight) of children and females • Biochemical assessment of the nutritional status of children and females regarding vitamin A, iron, iodine, zinc and folate status

Table 2.2 (contd): A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
2005	Wolmarans P, Danster N, Chetty J.[39] Energy and nutrient composition of South African maize meal. Technical report to the Maize Trust of South Africa	• Five mills representing the major suppliers of maize meal in South Africa in KwaZulu-Natal, North West Province, Northern Province and Gauteng	• Each of the five mills was requested to sample a 5 kg bag of unfortified super, special, sifted, unsifted maize meal and samp • Five samples of super and special maize meal each, three samples sifted maize meal and four samp samples were received • Four composite samples were prepared of each batch • No unsifted maize meal samples were received as none of the mills produced it	• Integrity tests were performed on all maize meal samples received to ensure it was unfortified as requested from the mills • Composite samples of super, special and sifted maize meal was prepared as well as samp • Unfortified composite samples were used for chemical analysis, preparation of soft, stiff and crumbly porridge, and for fortification of samples according to government regulations. Fortified composite samples were used for chemical analysis and preparation of soft, stiff and crumbly porridge • A fortification premix was obtained from a registered supplier, Roche Products, to fortify samples in the laboratory • Samples were chemically analysed for: moisture, ash, protein, total nitrogen, total fat, available carbohydrate (by difference), total dietary fibre and starch. The samples were analysed for 15 amino acids and nine fatty acids.

Table 2.2 (contd): A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
				Samples were analysed for the following minerals: calcium, iron, potassium, sodium, zinc, copper, manganese, phosphorus, chromium and magnesium. Vitamin A, C, E, B_6, thiamine, riboflavin, niacin, folic acid, pantothenate and biotin were included in the vitamin analyses. The energy content was calculated
2006	The Micronutrient Initiative.[33] Building the capacity of small millers: Training manual developed	• Small and medium sized mills in South Africa	• Six of the nine provinces in South Africa	• The MI and National Fortification Alliance conducted a survey to identify small and medium sized mills in the provinces and developed a training manual for small millers. The information was collated from multiple sources and intended to provide a single resource on maize meal and bread flour fortification
2008	Government Gazette.[40] Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972). Amendment of regulations relating to the fortification of certain foodstuffs (No. R. 1206).	• N/A*	• N/A*	• Amendment to the food fortification regulations (No. R. 504) published in 2003

* = Not Applicable

Table 2.2 (contd): A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
2008	Danster, Wolmarans, Buitendag, De Jager.[41] Energy and nutrient composition of South African wheat, wheat flour and bread. Technical report to the Winter Cereal Trust of South Africa.	• Representative samples of wheat obtained from the major wheat production areas in South Africa namely the Western Province, Free State and Orange River (area in the Northern Cape)	• Annually the South African Grain Laboratory receives representative wheat samples per class and grade, per silo, from all over South Africa to determine the wheat crop quality. In 2006, 182 X 5 kg of these crop samples were received from the Western Province, 137 X 5 kg from the Free State and 111 X 5 kg from the irrigation areas in the Orange River • Three composite samples of 30 kg each were prepared from the wheat samples obtained from the Western Province, Free State and Orange River (area in the Northern Cape)	• Of the 5 kg crop samples received from each production area the SAGL took 200 g to 300 g of each of the 5kg crop samples to prepare the three composite samples of 30 kg each to represent the three major production areas • Each 30 kg composite sample was subdivided. A 2 kg and 1 kg whole wheat sample was first obtained. The 2 kg whole wheat samples of each region were combined to represent a composited sample for analysis. The 1 kg whole wheat sample represented analysis for each region • The remaining 27 kg of wheat of each region was milled into white bread flour yielding 20 kg. The flour samples were used for chemical analysis of unfortified white bread flour, fortification of samples according to government regulations and preparation of unfortified and fortified bread for chemical analysis

Table 2.2 (contd): A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
				• A fortification premix, containing vitamin A, thiamin, riboflavin, niacin, vitamin B_6, folic acid, iron and zinc, was obtained from a registered manufacturer DSM Nutritional Products and used to fortify the flour samples. To avoid nutrient loss in the fortification premix, it was always stored and used while in a dark room • Samples were analysed for macronutrient (moisture, fat, available carbohydrate, protein, ash, total nitrogen, starch, total dietary fibre, total sugars) and micronutrient (calcium, iron, magnesium, phosphorous, potassium, sodium, zinc, copper, manganese, selenium, chromium) chemical nutrient analysis and the energy content subsequently calculated
2010	Yusufali, Sunley, De Hoop, Panagides.[34] Flour fortification in South Africa: Post-implementation survey of micronutrient levels at point of retail.	• Retail outlets in all nine provinces of South Africa	• 40 special maize meal packets, 106 super maize meal packets and 46 white bread flour packets were collected	• Collection of retail maize meal and white bread flour samples for post food fortification implementation survey and analysed for vitamin A, iron and nicotinamide levels • These levels were evaluated against the food fortification regulations

Table 2.2 (contd): A timeline of food fortification milestones in South Africa from 1989 to 2010

Year	Author and title	Study population/area	Sample size and selection	Activity
			• Food science and nutrition students attending four universities (UP**, US***, UFS#, NWU##) collected super and special maize meal and white bread flour packets from retail stores in their home towns during the 2010 summer vacation to ensure geographic diversity	

** = University of Pretoria, *** = University of Stellenbosch, # = University of the Free State, ## = North-West University

2.1.5.5 Food fortification and the role of the mills

The world's milling industry plays an important role in improving world health through flour fortification as it can improve micronutrient status. Flour fortification is described as a relatively simple technical procedure.[42] This process entails using a set amount of fortification premix which is added to a set amount of maize meal/flour and mixed well. The positive health benefits of fortified flour can, however, be influenced by factors such as vitamin A, riboflavin and folic acid loss over a period of time or exposure to sunlight (oxidation).[43]

Fortification premixes are required to maintain stability of micronutrients, especially during transportation of packets to various stores.[43] Manufacturers, importers or suppliers of fortification premixes are required to ensure that the quality standard for diluents and fortificants are in accordance with the standards in the latest edition of Food Chemicals Codex.[19] In South Africa, three different fortification premix manufacturers are currently (May 2015) registered with the Department of Health and millers are not prescribed as to which fortification premix to use.[43,44] Fortification premixes with a lesser stability could be used and this ultimately can affect the quality of the fortified product received by the consumer. It is for this reason that the levels of micronutrients added should be adequate to take into account these potential losses during distribution to the consumer, blending or storage of the fortified products.[43] In a study the stability of vitamin A in triple fortified salt in storage under controlled conditions, was tested for three months. The levels of vitamin A decreased to 65% respectively after three months illustrating the extent to which micronutrients can be lost during storage.[45] In a study by the Development Department of Hoffman-La Roche in the USA, the technological feasibility of the fortification of flour, rice and corn meal (maize meal) was investigated. For the flour experiment, this entailed fortifying flour with two different types of fortification premixes. Fortification premix A contained vitamin A, B_1, B_2, $B_{6,}$ folic acid, iron, niacin, zinc, calcium and magnesium while fortification premix B consisted of all the above-mentioned micronutrients except calcium and magnesium. After storing the flour for six months, results showed that no loss of vitamin and minerals occurred and this was possibly attributed to the moisture levels (12%) of the flour and storing it at room temperature. Additionally the authors observed that the fortification premixes blended well with the flour.[46]

Baking tests were conducted on bread and tests included looking at the retention of vitamins and minerals, taste differences, colour and proof time. Additionally, the volume of bread was compared between the two loaves prepared with two different fortification premixes. The baking tests revealed that less vitamin A and folic acid was retained in the bread prepared with fortification premix A (83%; 94% respectively) than fortification premix B (95%; 105% respectively). The authors concluded that since fortification premix B was prepared without calcium and magnesium, the presence of these two minerals in fortification premix A may have influenced the losses experienced at the moisture and temperature levels in the baking process. As for the yellow corn meal (maize meal) results, only minor variations were found in the vitamin levels after storage at room temperature for six months. After six months, the highest loss was for folic acid (16.6%) while for the rest of the micronutrients it was minor, specifically vitamin A (2.0%), iron (2.4%), riboflavin (2.9%). No loss occurred for vitamin B_6.[46]

2.1.5.6 Knowledge, attitudes and practices of mill managers

As indicated in the food fortification information guide for small millers, the DOH conducted a study among millers to ascertain their thoughts and concerns regarding the impending food fortification programme in 2002.[31] Various aspects (e.g. the importance of micronutrients for the body, date at which food fortification will be enacted in the country, overview of the fortification regulations under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), quality control measures millers will be obligated to practice and the critical role small millers also play in food fortification) relevant to food fortification were included in this information guide.[31] The above-mentioned aspects all contribute to the knowledge base of mill managers regarding food fortification. Without a good knowledge base, mill managers cannot effectively apply the principles of fortification.

A study done in 2006 by The MI and the National Fortification Alliance of South Africa identified small and medium-sized mills in six of the nine provinces to determine the millers' knowledge level about fortification and compliance with the fortification regulations.[33] The findings of this study was used to compile a training manual for millers.[33] This manual was collated to serve as a single resource for millers regarding maize meal and white and brown bread flour fortification which includes aspects such as i) why maize meal and flour (bread) was chosen as fortification vehicles; ii) the roles of the environmental health practitioners in fortification; iii) equipment suppliers; iv) addition of the fortificant; v) health and safety; vi) nutrition labelling; vii) quality assurance; viii) laboratory services; and ix) the calibration of microfeeders.[33]

In 2010 another investigation was conducted on the status of monitoring and evaluation of the South African staple food fortification programme. Government departments, fortification premix suppliers, millers and local authorities were interviewed to ascertain what constraints are hindering the effective implementation of the programme as high rates of vitamin A, iron and zinc deficiencies still prevailed.[47] The NFCS-FB-I showed that 63.6% and 45.3% of children under the age of five years were found to have a serum retinol concentration less than 20 µg/dL and suffered from zinc deficiencies (<65 µg/dL) respectively.[38] As mentioned in the strengthening monitoring and compliance report it was found that the initial support that existed for the programme had faded due to insufficient laboratory capability, poor communication between various stakeholders and lack of priority given to monitoring at local authority level. In addition, another factor that especially contributed to this reduced support included lack of awareness of the food fortification programme among millers. Hence the recommendations of the authors were that better education of staff at smaller mills would be beneficial.[47]

Although similar studies have been conducted regarding the knowledge, attitudes and practices of mill managers, the results of those studies are not freely available or in the public domain.[31,32,33]

2.2 Micronutrient malnutrition in the world

By 2003 it was estimated that 800 million people suffer from undernutrition of which the majority were from developing countries. Approximately 30% are in Southeast Asia, 25% in Africa, 8% in Latin America and the Caribbean.[3] Iron, iodine and vitamin A are the most common forms of micronutrient malnutrition worldwide. It is estimated that over two billion people are anaemic, under two billion have inadequate iodine nutrition and 254 million pre-school-aged children are vitamin A deficient.[9]

2.2.1 Micronutrient malnutrition among children in South Africa

In 1999, the first NFCS was conducted to determine the nutrient intakes and anthropometric status of children (1-9 years old).[28,29,30] Intakes of energy, calcium, iron, zinc, selenium, vitamin A, D, C and E, riboflavin, niacin, vitamin B_6 and folic acid of South African children were inadequate as it fell below two-thirds of the RDA.[29] The NFCS showed that maize meal, sugar, tea, whole milk and brown bread were the five most commonly eaten foods and maize meal and flour (bread) was chosen as the food vehicles for food fortification as it was shown to be the most commonly consumed staples in South Africa.[30]

South Africa introduced mandatory legislation for the fortification of maize meal and white and brown bread flour in 2003.[19] One of the objectives of a successful fortification programme includes monitoring and evaluation. "Evaluation includes: identifying patterns of consumer behaviour in terms of the purchase and consumption of the fortified food; determining intake of the nutrient of interest and contribution of the fortified food to this intake; and the impact of the public health problem being addressed".[48] At the onset of South Africa's food fortification programme, the NFCS-FB-I was planned to form an integral and critical part of the monitoring and evaluation of the food fortification policy in the country. The aim of the NFCS-FB-I survey was to determine the anthropometric, iron, iodine, zinc, folate and vitamin A status of children aged 1-9 years and of females of reproductive age (16-35 years old) in South Africa, as well as to describe the knowledge, attitude and practices with regards to food fortification and fortified food products.[38]

Despite the enforcement of mandatory food fortification of maize meal and white and brown bread flour in the country with vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folic acid, iron and zinc, high rates of vitamin A, iron and zinc deficiencies still prevailed among children and females.[38] Vitamin A status is classified by the World Health Organization criteria as follows: <10 µg/dL (vitamin A deficiency), 10-19 µg/dL (low/marginal vitamin A status), 20-29 µg/dL (adequate status), ≥30 µg/dL (normal/well nourished).[49] Upon comparison of the vitamin A status (<20 µg/dL) of children aged 1-6 years to the national data obtained from the SAVACG study all provinces displayed an increase in vitamin A deficiency.[27,38] Approximately 64% of the children (under five years of age) presented with a serum retinol concentration less than 20 µg/dL indicating a low vitamin A status.[38,49] Nationally for the 1-9 year old children, the mean zinc concentration was 68 µg/dL (normal value is 65 µg/dL), while 45.3% were zinc deficient.[38] When comparing the vitamin A status of children (under five years of age) who participated in the 2005 NFCS-FB-I (mean of 17.5 µg/dL) with the findings of the South African National Health and Nutrition Examination Survey conducted in 2012, vitamin A deficiency showed a decrease from 63.6% to 43.6%. This high percentage, however, presents a major public health problem.[50]

2.2.2 Dietary intake studies on adults in South Africa and micronutrient deficiencies

To date, a national dietary survey of adults in South Africa has not been undertaken. Several dietary intake studies in selected groups have, however, been conducted in South Africa from 1984 to 2002 before the introduction of the food fortification programme. Regional[51,52,53,54,55] quantitative dietary intake studies were undertaken among the main population groups of South African adults. Table 2.3 illustrates dietary intake studies conducted on South African adults between 1984 and 2002. In the below-mentioned studies, all population groups[51,52,53,54,55] had low vitamin and mineral intakes, e.g. vitamins A, B_6, B_{12}, C, riboflavin, thiamine, folate, niacin, iron, zinc, magnesium, calcium, copper.

In the Ciskei study[51] conducted among rural and urban black Africans, nutrient intakes were evaluated against the WHO recommendations[56] for energy, protein, vitamin A, thiamine, riboflavin, nicotinic acid, ascorbic acid, iron and calcium (Table 2.3). Findings indicated that 57% of lactating females (16-44 years old) had vitamin A intakes below 75% of the WHO recommendations (dietary intake assessed with a 24-hour dietary recall). Furthermore, the BRISK study conducted among the urban black African ethnic group revealed that in 78% of females (19-44 years old) and 89% of males (15-18 years old; 45-64 years old), the vitamin A intakes were less than 67% of the RDA.[54] In 1982, as part of a cross-sectional study to determine the prevalence of coronary risk factors in an urban mixed ancestry (CRISIC) ethnic group (n = 976) in the Cape Peninsula, participants participated in a 24-hour dietary recall interview and results indicated that 63-72% and 49-67% of males and females respectively aged 15-64 years, had a vitamin A intake below 75% of the RDA.[53]

For the white population group, the nutrient intake was investigated on a 15% random sub-sample of participants (n = 1 113) which formed part of the prevalence of risk factors (CORIS) study in three rural Afrikaans-speaking white communities.[52] It was observed that 36% and 38% of males and females respectively had vitamin A intakes below 75% of the RDA (in this study the vegetables and fruit food group was considered to be an important source for vitamin A). The Transition, Health and Urbanisation in South Africa (THUSA) study conducted among 1 571 black Africans residing in the urban and rural areas of the North West Province found that mean intakes of only females in the middle and upper class urban strata met the RDA for vitamin A.[55]

For riboflavin, low intakes were observed in black African lactating females as 56% had intakes below 75% of the WHO recommendations compared to only 32% of the females of the white population group.[51,52] In this study the milk food group was considered to be an important source of riboflavin.[52] Only 21% of males in the white population group had intakes below 75% of the RDA compared to 51-72% of coloured males across the age categories (15-64 years of age).[52,53] Where an intake below 75% of the RDA for a specific nutrient is observed among 20% or more of the participants, that nutrient requires attention.[57] While thiamine intakes proved to be adequate among black African groups in the Ciskei study[51], results of the BRISK and THUSA studies conducted among black adults found intakes to be inadequate.[54,55] Similarly, mean intakes among the mixed ancestry population group were below the RDA in all age groups and more than 50% of the study sample had intakes less than 75% of the RDA. Niacin intakes were below 75% of the WHO recommendations for 73% of black African lactating females.[51] This was also observed among black African adults in the BRISK and THUSA studies including the mixed ancestry ethnic groups whereas no data were reported for the white population group.[52,53,54,55] Mean vitamin B_6 intakes were low for black adults from the BRISK study; no data were reported in the Ciskei and the THUSA study.[51,54,55] For mixed ancestry and white females 77-87% and 88% respectively had intakes below 75% of the RDA for vitamin B_6.[52,53] Folate intake was not measured in the Ciskei study whereas the mixed ancestry and white population groups had remarkably low intakes, 91-99% of participants and 97% of females respectively fell below 75% of the RDA (Table 2.3).[51,52,53]

Considering the higher requirements for iron in females, mean iron intakes of females were low in the mixed ancestry, black African and Caucasian population groups.[51,52,53,54,55] More than 50% of the mixed ancestry ethnic group in all age groups fell below 75% of the RDA. Zinc intakes were not reported for the white population group nor for lactating females which formed part of the Ciskei study.[51,52] The dietary intakes of South African Indians have been determined previously, however, only the energy, macronutrient and cholesterol intakes were reported.

In the above-mentioned studies all population groups[51,52,53,54,55] had low vitamin and mineral intakes, e.g. vitamins A, B_6, B_{12}, C, riboflavin, thiamine, folate, niacin, iron, zinc, magnesium, calcium, copper. To address micronutrient deficiencies, strategies such as dietary diversification, supplementation and food fortification are adopted. Dietary diversification entails increasing both the quantity and range of micronutrient-rich foods, while supplementation involves supplying large doses of micronutrients, in pills, capsules or syrups. Through food fortification it is assumed that the fortified food is consumed in sufficient amounts by a large percentage of the targeted population. Additionally, it is preferable to utilise food vehicles that are centrally processed and most importantly with the support of the food industry.[9] Given the observation that individuals also displayed inadequate vitamin C intakes, a need was identified to address this problem. While fortification of foods may seem like an option, the main concern when using ascorbic acid is that substantial amounts are lost during food storage and preparation.[9]

Table 2.3: Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
1984	Richter, Langenhoven, Du Plessis, Ferreira, Swanepoel and Jordaan.[51] Nutritional value of diets of Blacks in Ciskei	n = 750 randomly selected healthy individuals from rural and urban areas were divided into four groups: 6-23 months old infants (n = 150), 2-3 years old toddlers (n = 282), 7-8 years old schoolchildren (n = 222), lactating females 16-44 years old (n = 96)	• 24-hour recall* • Diet history • Commonly used household measures (mugs, spoons of various sizes) • Standardised portions of bread and meat	• Energy • Protein • Carbohydrate • Total fat • Cholesterol • Vitamin A • Thiamine • Riboflavin • Nicotinic acid • Ascorbic acid • Iron • Calcium • Phosphorous	• Vitamin A intakes fell below 75% of the WHO** recommendations (6 000 IU) for 57% of lactating females***; 41% of schoolchildren had vitamin A intakes below 75% of the WHO recommendations (2 000 IU) • Nicotinic acid intakes were below 75% of the WHO recommendations (14.5 mg; 18.2-18.9 mg) for 75% of schoolchildren and 73% of lactating females respectively • Riboflavin intake for 52% and 56% of schoolchildren and lactating females respectively was below 75% of the WHO recommendations (1.3 mg; 1.7-1.8 mg) • Mean iron intakes (8.9 mg, 8.0 mg, 11.7 mg, 16.1 mg) of all four groups, exceeded WHO recommendations, however, intakes of 80% of lactating females was below 75% WHO recommendations • Mean thiamine intakes were adequate in all groups • Ascorbic acid intake for 27% and 30% of schoolchildren and lactating females were below 75% of the WHO recommendations (20 mg; 30 mg)

Table 2.3 (contd): Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
					• Calcium intakes were below 75% of the WHO recommendations (1 000 mg) for 73% of lactating females
1988	Langenhoven, Wolmarans, Groenewald, Richter and Van Eck[52] Nutrient intakes and food and meal patterns in three South African population groups[#]	• n = 1 113 white males (n = 454) and females (n = 659) 15-64 years old	• 24-hour recall • Food models • Portions of real food	• Energy • Total protein • Total carbohydrate • Total fat • Sugar • Vitamin A • Thiamine • Riboflavin • Vitamin B_6 • Folic acid • Ascorbic acid • Vitamin B_{12} • Iron • Calcium • Magnesium	• The percentage of males and females who consumed less than 75% of the RDA[##] for the different nutrients [and which food group (s) is considered to be an important source (although foods from other food groups also contribute to the total intake of such nutrients) are]: - Vitamin A: males 36%; females 38% - Folic acid: males 83%; females 97% - Ascorbic acid: males 35%; females 46% [Vegetables and and fruits]: - Calcium: males 35%; females 63% - Riboflavin: males 21%; females 32% [Milk]: -Vitamin B_6: males 63%; 88% females -Iron: males 16%; females 82% [Meat]: - Thiamine: males 24%; females 40% [Cereals]:

Table 2.3 (contd): Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
1988	Langenhoven, Steyn, Van Eck and Gouws[53] Nutrient intake in the Coloured population of the Cape Peninsula	• n = 976 randomly selected coloured individuals divided into eight sex and age groups, namely males and females aged 15-19 years (58 males and 53 females), 20-34 years (132 males and 144 females), 35-44 years (103 males and 112 females) and 45-64 years (185 males and 189 females).	• 24-hour recall • Food models and portions of fresh food used to train nurses for data collection	• Energy • Total protein • Total carbohydrate • Total fat • SFA • MUFA • PUFA • Cholesterol • Dietary fibre • Sugar • Vitamin A • Thiamine • Riboflavin • Nicotinic acid • Vitamin B_6 • Folic acid • Ascorbic acid • Vitamin B_{12} • Iron • Zinc • Calcium • Copper • Magnesium • Phosphorous • Potassium • Sodium	• The percentage of males and females who consumed less than 75% of the RDA for the different nutrients in the four age categories are: • Vitamin A: males 72% (15-19 years), 67% (20-34 years), 63% (35-44 years), 65% (45-64 years); females 49% (15-19 years), 60% (20-34 years), 58% (35-44 years), 67% (45-64 years) • Vitamin B_6: males 69% (15-19 years), 74% (20-34 years), 75% (35-44 years), 81% (45-64 years); females 77% (15-19 years), 81% (20-34 years), 82% (35-44 years), 87% (45-64 years) • Thiamine: males 50% (15-19 years), 53% (20-34 years), 57% (35-44 years), 55% (45-64 years); females 34% (15-19 years), 61% (20-34 years), 57% (35-44 years), 67% (45-64 years) • Riboflavin: males 72% (15-19 years), 51% (20-34 years), 58% (35-44 years), 57% (45-64 years); females 42% (15-19 years), 60% (20-34 years), 55% (35-44 years), 62% (45-64 years)

Table 2.3 (contd): Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
					• Nicotinic acid: males 14% (15-19 years), 20% (20-34 years), 18% (35-44 years), 27% (45-64 years); females 15% (15-19 years), 29% (20-34 years), 23% (35-44 years), 38% (45-64 years) • The highest percentage of inadequate ascorbic acid intake (<75% RDA) was in the 45-64 year age category for both males (66%) and females (63%) • More than 50% of male and female participants in each age category consumed less than 75% of the RDA for zinc, magnesium, copper, folic acid and calcium
1993	Bourne, Langenhoven, Steyn, Jooste, Laubscher and Van der Vyver[54] Nutrient intake in the urban African population of the Cape Peninsula, South Africa. The BRISK study.	• n = 983 African adults including 441 males and 542 females 15-64 years old divided into six sex and age groups, namely males and females aged 15-18 years (58 males and 61 females), 19-44 years (285 males and 364 females) and 45-64 years (98 males and	• 24-hour recall • Real foods used for training of fieldworkers • The dietary kit consisted of foam food models and standardised household utensils such as mugs, bowls and spoons which assisted with the quantification of portion sizes.[58]	• Energy • Protein (animal and plant) • Total carbohydrate • Fat (SFA, MUFA, PUFA) • Cholesterol • Dietary fibre • Sugar • Vitamin A • Thiamine • Riboflavin • Niacin • Vitamin B_6 • Folic acid	• The percentage of males and females who consumed less than 67% of the RDA for the different nutrients in the six groups are: • Vitamin A: males 89% (15-18 years), 83% (19-44 years), 89% (45-64 years); females 81% (15-18 years), 78% (19-44 years), 77% (45-64 years) • Ascorbic acid: males 81% (15-18 years), 79% (19-44 years), 83% (45-64 years); females 70% (15-18 years), 75% (19-44 years), 77% (45-64 years)

Table 2.3 (contd): Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
		117 females)		• Ascorbic acid • Vitamin B_{12} • Iron • Zinc • Calcium • Copper • Magnesium • Phosphorous • Potassium • Sodium	• Iron: males 51% (15-18 years), 32% (19-44 years), 42% (45-64 years); females 81% (15-18 years), 80% (19-44 years), 79% (45-64 years) • Calcium: males 77% (15-18 years), 71% (19-44 years), 66% (45-64 years); females 96% (15-18 years), 84% (19-44 years), 80% (45-64 years) • Copper: males 75% (15-18 years), 70% (19-44 years), 68% (45-64 years); females 84% (15-18 years), 87% (19-44 years), 91% (45-64 years) • Mean micronutrient intakes were below 67% of the RDA for roughly 50% of the participants for the following nutrients: riboflavin, niacin, thiamine, folic acid, vitamin B_6, vitamin B_{12} and zinc
2002	MacIntyre, Kruger, Venter and Vorster[55] Dietary intakes of an African population in different stages of transition in the North West Province, South Africa: the THUSA study	• n = 1 751 healthy adult volunteers including 743 males and 1 008 females 15-80 years old	• Quantified Food Frequency Questionnaire • Validated food portion photograph book • Common utensils and containers	• Energy • Protein (animal and plant) • Carbohydrate • Fat (SFA, MUFA, PUFA) • Cholesterol Fibre	• Mean vitamin A intakes of only females in the middle and upper class urban strata met the RDA (800 IU), while the FAO[###] safe levels of intake were met by all strata except for males of the farm dwellers stratum

Table 2.3 (contd): Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
				• Vitamin A • Thiamine • Riboflavin • Niacin • Folic acid • Vitamin B_{12} • Vitamin C • Iron • Zinc • Calcium	• Mean thiamine intakes of both genders did not meet the RDA, except for females of the upper class urban stratum • Only males of the upper class urban stratum met the RDA recommendations and FAO safe levels of intake (1.7 mg; 1.8 mg) for riboflavin, while mean intakes of females from the farm dwellers, middle- and-upper class urban stratum met the RDA recommendations and FAO safe levels of intake (1.3 mg; 1.3 mg) • Mean niacin intakes met the RDA (15.0 mg; 19.0 mg) in the upper class urban strata for females and males, while no other stratum met the RDA recommendations or FAO safe levels of intake • Males and females from the farm dwelling stratum did not meet the RDA (200 µg; 180 µg) for folic acid • Vitamin C intakes of males and females only in the upper class urban stratum met the RDA (60 mg)

Table 2.3 (contd): Dietary intake studies conducted among South African adults between 1984 and 2002

Year	Authors and title	Study population	Dietary intake data research tools	Nutrients reported	Summarised findings for micronutrients
					• Only males from the upper class urban stratum met the RDA for iron while intakes for females in all strata were below the RDA (15.0 mg) and FAO (24.0 mg) safe levels of intake respectively • Zinc intakes were below the RDA recommendations and FAO safe levels of intake for both males (15.0 mg; 9.4 mg) and females (12.0 mg; no recommendation) respectively in all strata

[*] Nutrient intake data reported for 24-hour recalls collected
[**] World Health Organization
[***] Females aged 16-19 years and adult lactating females >19 years
[#] Nutrient intake data reported for 24-hour recalls collected of white population group only
[##] Recommended Dietary Allowance
[###] Food and Agricultural Organization

The type of food consumed is important and studies were conducted to investigate the nutritional quality of diets of black, coloured and white population groups.[52] In the mixed ancestry ethnic group the mean portion of milk consumed from the milk group was lower than the recommended two portions a day and therefore, the calcium and riboflavin intakes were low. While many participants consumed vegetables and fruit, it was not sufficient to meet the number of portions recommended and therefore low vitamin A and C and folic acid intakes were observed in all groups. As for the cereal group, the intakes were high; however, the high consumption of refined cereals among the mixed ancestry and white females resulted in a low magnesium and thiamine intake. The authors' conclusions on these findings were that all three groups' diets were low in micronutrients (refer to Table 2.3).

In 1995, as part of the Human Sciences Research Council Omnibus Survey, qualitative dietary data were collected regarding South Africans habitual diet. The questionnaire utilised consisted of 10 sections of which one focused on eating habits. The section on eating habits was comprised of eight questions enquiring about the intake of fruit and vegetables, milk, pure fat foods (margarine, butter and oil), what they considered as their staple food and the kind of bread consumed. The intake of bread was not quantified. The sample comprised 2 000 South Africans of which 38% indicated having no staple food while 27% specified maize, 14% bread, 10% meat, 6% rice and 4% other foods as their staple food. The white and Indian South African population groups followed a mixed diet (no staple food), whereas maize was indicated as the staple food for forty nine percent of the black African ethnic group, while mixed ancestry participants (23%) indicated bread as their staple food.[59] The NFCS showed that maize meal and bread were among the top ten foods consumed by South African children. The other foods among the top ten were white sugar, tea, whole milk, white rice, hard margarine, chicken and potatoes.[30]

A national consumer survey conducted in 2011 by a reputable South African leading grain-based manufacturing company provided information on maize intake data of a national sample of adults aged 16-88 years old. Intakes stratified by province indicated higher maize consumption in the Limpopo, Mpumalanga and KwaZulu-Natal provinces, followed by the Free State, Northern Cape, Gauteng and Eastern Cape with similar intakes and the North West and Western Cape with the lowest intakes. Males consumed on average more raw maize (approximately 170 g) compared to females (approximately 142 g).[60]

2.3 Summary

In summary, studies on South African adults and children showed that the diets were low in micronutrients. The intake of micronutrients in the studies mentioned above could explain the deficiencies observed. Findings of the most recent study[50] among children compared to the findings of the 2005 NFCS-FB-I survey[38], indicated that the vitamin A and iron status of children aged 1-5 years of age has improved, however, at national level the prevalence of vitamin A deficiency was found to be 43.6%, which still indicates a public health problem of significance. Additionally, the zinc status, nationally among children 1-9 years of age was found to be poor as 45.3% were zinc deficient.[38] Food fortification was implemented in South Africa to improve the micronutrient intake of the population. However, since concerns have arisen regarding the effectiveness of the fortification programme, an investigation into the knowledge, attitudes and practices regarding food fortification among the maize meal and wheat flour mill managers in South Africa (Chapter 3) and determination of the contribution of maize meal to the micronutrient intake of South African adults, aged 16-88 years old (Chapter 4) is warranted.

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Chapter 3

Knowledge, attitudes and practices regarding food fortification among maize meal and wheat flour mill managers in South Africa[a]

Danster-Christians N, Daniels L, Burger H-M, Laubscher R, Wolmarans P.

3.1 Abstract

Objective: The aim of this study was to gather information on the knowledge, attitudes and practices regarding food fortification among the maize meal and wheat flour mill managers in South Africa.

Design: Cross-sectional study

Setting: All nine provinces in South Africa

Participants: Staff members (n = 30) responsible for overseeing fortification at maize meal and wheat flour mills in South Africa were recruited for participation in this study.

Methods: Data were collected by means of a pretested self-administered questionnaire available in English and Afrikaans distributed to 211 study participants in South Africa via email, post and fax.

Results: The response rate was 14.2% (n = 30). More than half (n = 16; 53.3%) of the participants knew when food fortification became mandatory in South Africa. Twenty three participants (76.6%) knew that food fortification is not the only method of addressing micronutrient deficiencies. Fifty percent (n = 15) of the participants felt that food fortification does not demand a lot of time and work. Almost all (n = 26; 86.6%) of the mills modified their milling enterprises to comply with the requirements of the food fortification regulations. Only 50.0% of the mill managers knew with which vitamins maize meal is fortified. The overall knowledge score was average (52.2%).

Conclusion: Despite the fact that more than half of the participants correctly answered the knowledge questions, there were still shortcomings regarding food fortification practices among small and medium-sized mills participants. The results of this study provide a basis for improving areas of fortification practices at mill level.

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3.2 Introduction

Food fortification as defined by the Codex Alimentarius refers to the "*addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population group*".[1]

In 1994 the South African Vitamin A Consultative Group (SAVACG) found that approximately 33% of children (aged 6-71 months) had a marginal vitamin A status (serum vitamin A concentration <20 µg/dL). Country-wide, one in five children were found to be anaemic and iron-deficiency anaemia was found in one in every 20 children.[2] Following this survey, a recommendation was made that a food fortification programme should be started to address the micronutrient deficiencies in the country.[3]

In 2002, as mentioned in the food fortification information guide for small millers, the Department of Health (DOH) conducted a questionnaire study on millers to ascertain their thoughts and concerns regarding the impending food fortification programme. The 13-page information guide was developed for millers and included various aspects relevant to food fortification, e.g. the importance of micronutrients for the body, date at which food fortification will be enacted in the country, overview of the fortification regulations under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), quality control measures millers will be obligated to practice and the critical role small millers also play in food fortification.[4] The results of the questionnaire study on millers is, however, not in the public domain.

By 2003 mandatory regulations were passed in South Africa that any person who manufactures, imports or sells maize meal and wheat flour has to comply with the set regulations for which non-compliance will be deemed an offence.[5] Small, medium, large, urban, peri-urban and rural millers all have to abide by the regulations.[3]

Food fortification was adopted, amongst other strategies such as vitamin A supplementation and food diversification, by South Africa in 2003 to improve the micronutrient status of the population. The 2005 National Food Consumption Survey Fortification Baseline Survey, however, indicated deterioration in the vitamin A and iron status of children and females in comparison to the 1994 SAVACG findings.[2,6] The South African National Health and Nutrition Examination Survey conducted in 2012 indicated an improvement in the vitamin A and iron status of children under five years of age, however, it still remains a public health problem.[7]

In 2006, The Micronutrient Initiative (MI) and the National Fortification Alliance of South Africa embarked on a survey to identify small and medium-sized mills in six of the nine provinces to determine the miller's knowledge level about fortification and compliance with the fortification regulations. The findings of this study was used to compile a training manual for millers.[8] This manual was developed to serve as a single resource for millers regarding maize meal and white and brown bread flour fortification which included aspects such as i) why maize meal and wheat flour was chosen as fortification vehicles; ii) the roles of the Environmental Health Practitioners (EHP) in fortification; iii) equipment suppliers; iv) addition of the fortificant; v) health and safety; vi) nutrition labelling; vii) quality assurance; viii) laboratory services; and ix) the calibration of microfeeders.[8]

In 2010 another investigation was conducted on the status of monitoring and evaluation of the South African staple food fortification programme. Government departments, fortification premix suppliers, millers and local authorities were interviewed to ascertain what constraints are hindering the effective implementation of the programme as high rates of vitamin A, iron and zinc deficiencies still prevailed. It was found that the initial support that existed for the programme had faded dramatically. One of the factors that especially contributed to this reduced support included lack of awareness of the food fortification programme among millers. Hence their recommendations were that better education of staff at smaller mills would be beneficial.[9]

Although similar studies have been conducted regarding the knowledge, attitudes and practices of mill managers, the results of those studies are not freely available.[4,8] Since concerns have arisen regarding the effectiveness of the fortification programme, it created a need to once again determine the knowledge, attitudes and practices regarding food fortification among mill managers and to share those results, which was the aim of this study.

3.3 Methods

3.3.1 Study design

The study was conducted as a descriptive cross-sectional study.

3.3.2 Study population

The South African Grain Laboratory, the South African Grain Information Services (SAGIS)[10], the National Chamber of Milling (NCM)[11] and the DOH[12] were contacted to obtain the list of maize meal and wheat flour mills in South Africa. A comprehensive list was only obtainable from SAGIS, which included all the companies/mills involved in the processing of maize meal/wheat flour. The original list (November 2010) consisted of 523 maize meal and 486 wheat flour mills. Only the companies (n = 223) involved in the production of maize meal/wheat flour for human consumption as indicated on the SAGIS list were identified for the study. These mills were then contacted telephonically to identify the participants at each mill. The mill/technical/quality assurance managers responsible for overseeing fortification at the respective mills were recruited for participation in this study.

3.3.3 Inclusion criteria

All South African mills manufacturing maize meal and wheat flour for human consumption were included in the study. The staff members responsible for overseeing fortification at the respective mills were recruited for participation in this study.

3.3.4 Exclusion criteria

All South African companies processing maize meal or wheat flour for animal consumption were excluded from the study as well as personnel at the mill who did not oversee the fortification process.

3.3.5 Data collection

A questionnaire (Addenda 1 and 2) comprising six sections addressing socio-demographic information of the participants, type and amount of grain milled at the mill, knowledge of the participants (Section C of questionnaire), attitudes of the participants towards food fortification (Section D of questionnaire), fortification practices utilised at the mill (Section E of questionnaire) and sources on food fortification information used by the participants. Multiple choice questions were included in the questionnaire as well as open and closed-ended questions.

To test the questionnaire as a research instrument and to ensure content validity the questionnaire was sent to a representative within the maize meal industry and to two senior scientists at the unit previously known as the Nutritional Intervention Research Unit of the Medical Research Council (MRC). The representative from the industry responded on the type of questions while the two scientists conducted content validity. One of the scientists serves as a member on the national fortification working group initiated by the DOH, while the other has worked closely alongside representatives of the maize meal industry. Any questions that were misunderstood from the questionnaire were revised and included thereafter. A shortcoming could have been that the questionnaire was not also pre-tested on a sample of the study population, i.e. to test for face validity. To assess the attitudes of participants, a four-point Likert-scale was used, ranging from “strongly agree” to “strongly disagree”. A four-point Likert-scale was used to ensure that each participant expresses an opinion and to avoid obtaining neutral responses.[13] The questionnaire (Addenda 1 and 2) consisted of seven four-point Likert-scale questions, 23 open-ended and 15 closed-ended questions.

The data were collected from October to December 2011 and March to April 2012 by means of a pretested, self-administered questionnaire. This questionnaire was available in both English (Addendum 1) and Afrikaans (Addendum 2) as these were the languages used by the study participants. A cover letter in English (Addendum 3) and Afrikaans (Addendum 4) explaining the aim of the study was also attached to the questionnaire. The questionnaire included a letter inviting people to participate, a brief background and purpose of the study and an information leaflet (Addendum 5) stating that completion of the form implies informed consent. Additionally it stated that all information supplied to the researcher will be treated as confidential, that information will be used for this study only and that all documentation where names were used will be seen by the principal researcher only. All responses received via email were de-linked from the response to ensure anonymity.

Two hundred and twenty three questionnaires were sent either by email (n = 158) or post (n = 65) to the maize meal and wheat flour mills. Questionnaires sent out by post included a self-addressed envelope. Follow-up phone calls were made to all the companies to which postal questionnaires were sent. Ten companies were unreachable via telephone and this therefore made follow-up impossible. One participant received the postal questionnaire, but was not interested in the study and one company was indeed a depot and not a mill as originally identified. The time that lapsed between the first call and the distribution of questionnaires was 11 months, due to unforeseen circumstances and may have been too long. Some mills could have closed down during this period and this could explain why ten companies previously contacted were unreachable after the questionnaires were distributed. As a result, the above-mentioned 12 companies were excluded from the list resulting in 211 companies in the final list 158 (74.9%) emailed and 53 (25.1%) questionnaires posted). Questionnaires were sent to all nine provinces: Free State (n = 56), KwaZulu-Natal (n = 36), Gauteng (n = 29), North West (n = 26), Mpumalanga (n = 22), Western Cape (n = 18), Limpopo (n = 15), Eastern Cape (n = 7) and the Northern Cape (n = 2).

Reminder emails were sent out maximum twice to those who received the questionnaire electronically. A total of 21 questionnaires were received at that stage. As a final attempt to increase the response rate to at least 65 (30%) questionnaires, it was decided to select a random sample from the original mills identified from each province and again request participation. Forty four (44) companies were again contacted to encourage participation. After these participants agreed to partake, the questionnaire was immediately emailed and a few managers requested a faxed questionnaire. Thereafter, two reminder follow-up phone calls were made to each of the 44 participants to try and increase the response rate. This procedure resulted in nine (20.5%) extra questionnaires being returned, bringing the final number of returned questionnaires to 30 (response rate of 14.2%). In consultation with the supervisor, the principal investigator decided at that stage to stop recruitment as the response still remained low after several attempts.

3.3.6 Ethical approval

Ethical approval was obtained from The Health Research Ethics Committee of the Faculty of Health Sciences, Stellenbosch University (Addendum 6: Ethics reference number N10/11/374; 23 November 2010) and from the MRC Ethics Committee (Addendum 7: Protocol ID EC11-004; 1 April 2011).

3.3.7 Data analysis

Data were captured in Microsoft Excel 2003 by the principal researcher and were analysed by a statistician from the Biostatistics Unit at the MRC using SAS version 9.3. Due to the small number of mills, small and medium-sized mills formed one category and large mills another. For each of the three knowledge questions regarding food fortification in the two categories, the number and percentage of correct answers were determined. Fisher's exact test was used to test for differences between the mill categories.

A composite score was calculated for the three knowledge questions regarding food fortification and expressed as a percentage. Mean percentage scores were calculated for the following three educational categories: grade 12; diploma/certificate; and degree/post-graduate qualification and the Chi-Square test was used to assess whether there was a difference in knowledge between these three educational categories.

An overall knowledge score was calculated for each participant and expressed as a percentage using the nine questions about food fortification, i.e. the mineral and vitamins used to fortify maize meal and white bread flour, benefits of fortification and how long fortification will continue. To determine whether the knowledge was poor, average or adequate the following classification was used: 0-40% (poor); 41-69% (average); 70-100% (adequate). An error was observed in the questionnaire and those responses were therefore excluded from the knowledge score calculation.

For correctly answered practice questions, a score was calculated from the total number of practice questions (n = 6) and expressed as a percentage. Mean percentage scores were then calculated for the two mill categories (small- plus medium-sized mills versus the large-sized mills). An ANOVA was used to assess whether there were differences between these two categories of the mills in terms of the percentage scores for practices. One mill was omitted from the practice scores calculation due to incompleteness of the responses.

Using the seven attitude statements, which were measured with a Likert-scale, the responses of “strongly agree/agree” and “strongly disagree/disagree” were changed to form seven binary attitude variables as 1 and 0 respectively.

Comparisons were drawn between the knowledge, attitudes and practices of mill managers regarding food fortification using the T-test, assessing the effect of knowledge and practices on each of the seven attitude responses as outcome. Pearson’s correlation coefficient test was used to assess the correlation between knowledge and practice variables. A p-value <0.05 was regarded as statistically significant.

To determine whether the mills obtained their fortification premixes from manufacturers that were registered with the DOH, fortification premix suppliers listed on the DOH website was checked against the suppliers indicated by the mills. Registration with the DOH is valid for a period of one year[5] and since the data collection process took place during October-December 2011 and March to April 2012, manufacturers registered within that timeframes were regarded as registered.

3.4. Results

3.4.1 Response

Thirty (14.2%) of the questionnaires were returned after several follow-up attempts to increase the response rate. Thirteen (43.3%) were returned by e-mail, 10 (33.3%) by fax and seven (23.3%) were returned by post. Responses were received from mills in all nine provinces of South Africa; eight (26.7%) were received from Gauteng, six (20.0%) from the Free State, four (13.3%) from KwaZulu-Natal, three each (30.0%) from North West, Mpumalanga and Western Cape and one each (10.0%) from Limpopo, the Eastern and Northern Cape respectively (refer to Table 3.1). Questionnaires were completed by various individuals overseeing fortification at the different mills. Twenty three participants indicated their working title (e.g. managing director, manager, head miller) at the mill while seven questionnaires were returned without working titles. Due to the limited number of questionnaires received, those returned without working titles were included in this study.

Table 3.1: Number of questionnaires distributed to the different provinces and response rate

Province	Questionnaires distributed			Number received back per province (%)	Percentage received of total number distributed
	Email n	Post n	Total n		
Free State	35	21	56	6 (20)	2.84
KwaZulu-Natal	29	7	36	4 (13)	1.89
Gauteng	21	8	29	8 (27)	3.79
North West	22	4	26	3 (10)	1.42

Table 3.1 (contd): Number of questionnaires distributed to the different provinces and response rate

Province	Questionnaires distributed			Number received back per province (%)	Percentage received of total number distributed
	Email n	Post n	Total n		
Mpumalanga	16	6	22	3 (10)	1.42
Western Cape	13	5	18	3 (10)	1.42
Limpopo	13	2	15	1 (3)	0.47
Eastern Cape	7	0	7	1 (3)	0.47
Northern Cape	2	0	2	1 (3)	0.47
	158	**53**	**211**	**30 (100)**	**14**

3.4.2 Characteristics of the mills

The MI classifies small-scale mills as those that mill less than one metric ton/hour (MT/hr), medium-scale mills can mill 1 to 3 MT/hr and large mills can mill 2 MT/hr.[14] Participants were requested to report the tons of grain (maize/wheat) milled per day and daily operating hours. The total grains produced per day indicated by the participants did not correspond to the size classification/milling capacity as indicated by some of them, therefore the categories identified by them were accepted. Fourteen (46.7%) of the mills were classified as large mills, 13 (43.3%) were medium-sized mills and 3 (10.0%) were small mills. More than half (n = 20; 66.7%) of the participating mills were maize mills, 23.3% (n = 7) were wheat mills and 10.0% (n = 3) indicated that they manufactured both maize meal and wheat flour at the same mill.

The number of employees varied between the mill sizes, small (1-49), medium (2-63) and large mills (3-380). Ten (33.3%) mills were in operation 24 hours per day and included medium- and large-sized mills. The maximum amount of maize meal produced reached 1 320 tons a day compared to 500 tons of wheat flour. Sixteen (53.3%) of the mills operated for more than half the year (>182days), while eleven (36.7%) operated for more than 300 days a year. Almost half (n = 14; 46.7%) of the mills indicated that they did not belong to the NCM, eleven (36.7%) belong to the NCM, three (10.0%) companies did not provide information regarding this question, while two (6.7%) indicated that they are registered with SAGIS.

3.4.3 Characteristics of the participants

Forty percent (n = 12) of the participants was in the age category of 51-60 years while about 16.7% chose not to divulge their age (Table 3.2). Six (20.0%) of the participants had a grade 12 certificate and twenty (66.7%) participants obtained further qualifications.

Table 3.2: Characteristics of the participants (n = 30)

Variable	n	%
Age category (years)		
30-40	5	16.7
41-50	5	16.7
51-60	12	40.0
61-70	3	10.0
No information	5	16.7
Highest education obtained		
Less than Grade 12	1	3.3
Grade 12	6	20.0
Diploma/certificate	14	46.7
Degree	1	3.3
Post-graduate qualification	5	16.7
No information	3	10.0
Gender		
Male	26	86.7
Female	4	13.3

3.4.4 Knowledge regarding food fortification

More than half (n = 16; 53.3%) of the participants correctly identified the date at which food fortification became mandatory in South Africa (Table 3.3). Similarly more than half (n = 16; 53.3%) of the participants correctly indicated that food fortification will continue in South Africa forever. The size of the mills had no influence on the fact that participants knew that food fortification is not the only method of addressing micronutrient deficiencies, although the larger-sized mills scored higher (78.6%) on the knowledge questions, the difference was not statistically significant (p = 1.000).

Table 3.3: Number and percentage of participants who correctly answered questions regarding food fortification

Question and *answer*	Small- and medium-sized mills n = 16	Large mills n = 14	Total n = 30	Diff.*
	Number and (percentage) correct answers			p-value*
Since when is food fortification mandatory in South Africa? *Correct answer: 2003*	8 (50.0)	8 (57.1)	16 (53.3)	0.730
For what period will fortification of maize meal and wheat flour continue in South Africa? *Correct answer: Forever***	7 (43.8)	9 (64.3)	16 (53.3)	0.299
Food fortification is the only method of addressing micronutrient deficiencies *Correct answer: No, there are other methods as well*	12 (75.0)	11 (78.6)	23 (76.7)	1.000

* Difference between small plus medium sized mills and large mills. Fisher's exact test
** For the purposes of this study forever was indicated as the correct answer

When comparing the mean knowledge percentage scores of participants among the different categories of qualifications (grade 12 certificate = 39%; diploma/certificate = 67%; degree/post-graduate qualification = 83%), the participants with degrees and postgraduate qualifications scored the highest, but the difference was not significant (p = 0.077).

3.4.5 Knowledge regarding vitamins and minerals added

The regulations stipulate that all maize meal, white and brown bread flour milled in South Africa must contain specified amounts of vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc.[5] Twelve (60.0%) participants from the maize meal mills (n = 20) knew which vitamins are used to fortify maize meal and 14 (70.0%) could correctly identify the minerals used. At the mills manufacturing both maize meal and wheat flour (n = 3), all the participants (n = 3; 100%) knew which vitamins and minerals were added to maize meal (Table 3.4).

Table 3.4: Answers by mill managers regarding the vitamins and minerals added to *maize meal* as stipulated by the fortification legislation

Possible answers participants could choose (correct answer in *italics*)	**Maize mills n = 20**	**Wheat mills n = 7**	**Maize and wheat mills n = 3**	**Total number of mills n = 30**
Vitamin combinations				
Niacin, Thiamine, Folic acid, Riboflavin, Vitamin A, Pyridoxine	12	0	3	15
Thiamine, Riboflavin, Niacin, Vitamin C, Vitamin A, Vitamin D	3	0	0	3
Vitamin D, Thiamine, Folate, Riboflavin, Niacin, Vitamin A	0	0	0	0
Unsure	4	2	0	6
None of the above	1	0	0	1
No information	0	5	0	5
Mineral combinations				
Zinc and Iron	14	0	3	17
Magnesium and Selenium	0	0	0	0
Calcium and Manganese	0	0	0	0
Iron and Calcium	1	0	0	1
Unsure	4	2	0	6
None of the above	0	0	0	0
No information	1	5	0	6

In Table 3.5, 71.4% (n = 5) of the seven wheat mill participants correctly identified the vitamins and only 57.1% indicated the correct minerals used to fortify white bread flour. At the mills manufacturing both maize meal and white bread flour, only 2 of 3 participants knew which vitamins and minerals have to be added to white bread flour.

Table 3.5: Answers by mill managers regarding the vitamins and minerals added to *white bread flour* as stipulated by the fortification legislation

Possible answers participants could choose (correct answer in *italics*)	Maize mills n = 20	Wheat mills n = 7	Maize and wheat mills n = 3	Total number of mills n = 30
Vitamin combinations				
Niacin, Thiamine, Folic acid, Riboflavin, Vitamin A, Pyridoxine	0	5	2	7
Thiamine, Riboflavin, Niacin, Vitamin C, Vitamin A, Vitamin D	0	0	0	0
Vitamin D, Thiamine, Folate, Riboflavin, Niacin, Vitamin A	0	0	1	1
Unsure	3	0	0	3
None of the above	0	0	0	0
No information	17	2	0	19
Mineral combinations				
Zinc and Iron	0	4	2	6
Magnesium and Selenium	0	0	0	0
Calcium and Manganese	0	0	0	0
Iron and Calcium	1	0	0	1
Unsure	4	1	0	5
None of the above	0	0	0	0
No information	15	2	1	18

3.4.6 Attitudes towards food fortification

Fifty percent (n = 15) of the participants strongly disagreed/disagreed with the statement that food fortification of maize meal/wheat flour at the mills demands a lot of time and extra work from the staff. Approximately 47% (n = 14) strongly agreed/agreed with the above-mentioned statement and 3.3% provided no information. The majority (n = 18; 60.0%) of the participants also strongly agreed/agreed with the statement that food fortification costs the mill a lot of money, which could have been spent on other needs. Approximately 77% of the participants strongly agreed/agreed that the fortification mix which the mill has to purchase is too expensive while 20.0% felt that it was not and 3.3% did not answer/respond to this question. The majority (n = 23; 76.7%) of the participants strongly agreed/agreed that the Environmental Health Practitioners should visit the mill regularly to check whether the regulations are being complied with, while 16.7% strongly disagreed/disagreed with the statement and 6.7% did not answer/respond to this question. Roughly 57% of the participants did not agree with the statement that fortification creates a better quality product, while 40.0% strongly agreed/agreed with the statement and 3.3% did not answer/respond to this question.

3.4.7 Knowledge versus attitude

The mean knowledge scores for mill managers (percentage) and their responses to the statements indicating their attitude (strongly agree/agree and strongly disagree/disagree) were compared to determine whether differences were statistically significant (Table 3.6). Participants who responded that food fortification does not demand a lot of time had a higher (57.8%) knowledge score than those (47.6%) participants who felt that it was time consuming. This difference, however, was not statistically significant (p = 0.314) (Table 3.6).

With regards to whether food fortification costs the mill a lot of money, participants with a higher (64.6%) knowledge score indicated that it does not cost the mill a lot compared to those (45.7%) who felt it does. This difference was marginally significant (p = 0.062).

The mean knowledge scores and attitudes did not differ significantly, except for one statement, i.e. participants who responded that food fortification creates a better quality product had a significantly (p = 0.011) higher (67.6%) knowledge score than those (44.4%) who indicated it does not. With regards to whether food fortification is considered essential for the nutritional well-being of South Africans, those participants with a higher (58.2%) knowledge score felt that it is essential compared to those (38.3%) who did not. The difference was marginally significant (p = 0.057).

Table 3.6: Influence of mean knowledge scores (%) on attitudes of mill managers

Attitude statement	Strongly agree/Agree Number* Mean (SD)**	Strongly disagree/Disagree Number* Mean (SD)**	Difference	p-value***
Food fortification of maize meal/wheat flour at the mills demands a lot of time and extra work from the staff	14 47.6 (30.3)	15 57.8 (22.7)	10.2	0.314
Food fortification costs the mill a lot of money which could have been spent on other needs	18 45.7 (26.4)	11 64.6 (23.7)	19.0	0.062
The fortification premix is too expensive	23 50.7 (25.9)	6 61.1 (30.4)	10.4	0.405
The Environmental Health Practitioners, should visit the mill regularly to check whether the regulations are being complied with	23 52.7 (27.5)	5 55.6 (28.3)	2.9	0.833
The monthly records of the amount of fortification premix added to maize meal/wheat flour creates a lot of paperwork	16 50.0 (33.0)	12 57.4 (17.0)	7.4	0.485
The fortification of maize meal/wheat flour creates a better quality product	12 67.6 (24.8)	17 44.4 (20.8)	-23.1	0.011
Food fortification is essential for the nutritional well-being of all South Africans	21 58.2 (27.4)	9 38.3 (18.5)	-19.9	0.057

*sample size does not add up to 30 as some participants did not indicate an attitude; **Knowledge score, *** T-test

3.4.8 Knowledge versus practice

A positive correlation (r = 0.335; p = 0.076) was found between the knowledge of the mill managers and the practice scores. The practice score of one mill was omitted.

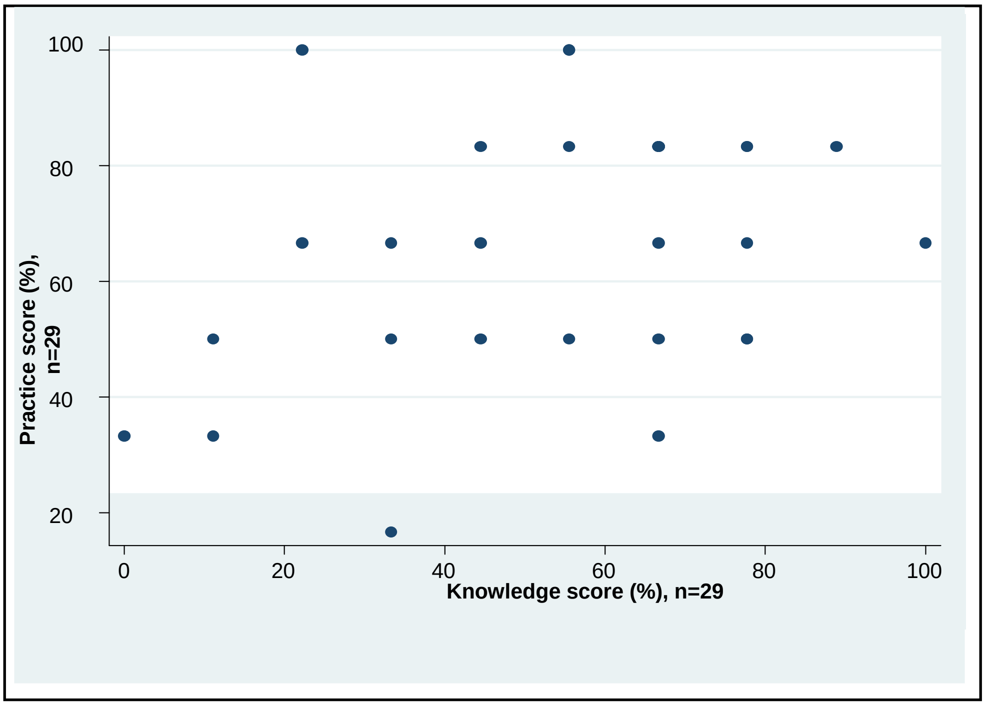

Figure 3.1: Scatterplot of knowledge (%) and practice (%) scores of mill managers (n=29)

3.4.9 Practice versus attitude

No significant differences were found between the practice scores and attitude statements of the mill managers (Table 3.7).

Table 3.7: Influence of mean practice scores (%) on attitudes of mill managers

Attitude statement	Strongly agree/Agree Number* Mean (SD)**	Strongly disagree/Disagree Number* Mean (SD)**	Difference	p-value***
Food fortification of maize meal/wheat flour at the mills demands a lot of time and extra work from the staff	13 66.7 (18.0)	15 66.7 (26.0)	0	1.000
Food fortification costs the mill a lot of money which could have been spent on other needs	17 63.7 (22.2)	11 71.2 (22.5)	7.5	0.394
The fortification premix is too expensive	22 65.9 (23.8)	6 69.4 (16.4)	3.5	0.737
The Environmental Health Practitioners, should visit the mill regularly to check whether the regulations are being complied with	22 68.2 (22.9)	5 63.3 (21.7)	-4.9	0.671
The monthly records of the amount of fortification premix added to maize meal/wheat flour creates a lot of paperwork	15 65.6 (18.3)	12 69.4 (27.4)	3.8	0.663
The fortification of maize meal/wheat flour creates a better quality product	12 69.4 (22.3)	17 63.7 (22.2)	-5.7	0.502
Food fortification is essential for the nutritional well-being of all South Africans	20 67.5 (19.1)	9 63.0 (28.6)	-4.5	0.617

*sample size does not add up to 30 as some participants did not indicate an attitude and one mill's practice score was omitted due to an incomplete section; ** Practice score, ***T-test

3.4.10 Food fortification practices at the mills

The large-sized mills obtained a higher score (70.2%) than the small- and medium-sized mills (62.2%) for successful food fortification practices at the mill, but the difference was not statistically significant (p = 0.312). According to the fortification regulations under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), certain practices have to be adhered to by manufacturers of maize meal and white and brown bread flour.[5] Successful practices at the mills were determined using data from the questionnaire responses and assessing storage conditions of fortification premixes, monitoring of the expiry dates of the fortification premixes and whether tests were performed on the maize meal and wheat flour to ensure it is fortified.

Almost all (n = 26; 86.7%) the mills implemented changes to comply with the fortification legislation. Many of the changes included the implementation of microfeeders at the mill for dispensing the fortification premix. The participants of the remaining mills (n = 4; 13.3%) indicated that they have not implemented any changes and one of them indicated that this was due to financial constraints.

3.4.11 Food fortification premixes

The mills obtained fortification premixes from 6 different registered manufacturers or suppliers or importers or distributors and one mill indicated that the supplier was a farmer. Manufacturers of maize meal and white- and brown bread flour should only obtain fortification premixes at companies that have registered with the DOH.[5] Some mills indicated the distributor from which the fortification premix was obtained as opposed to the manufacturer or supplier or importer. As stated on the DOH list the registered manufacturers or suppliers or importers are responsible for the quality of the distributed product and for this reason the responsible supplier companies was used in this study in the event a distributor name was supplied. Eighty percent of the mills indicated from which supplier they bought the fortification premix, while 13.3% were unsure and 6.7% did not provide this information. Supplier A was the preferred supplier for 30.0% of the mills and for the other mills figures varied between 3.3% and 13.3% (Table 3.8).

Participants (n = 19; 63.3%) reported that the fortification premix was stored according to instructions by the supplier/packaging (Table 3.8). To avoid nutrient loss of vitamins which are light sensitive, fortification premixes should always be stored and used under subdued lighting.[15] Seventy six percent disagreed that the fortification premix packets can be stored anywhere as long as the packet is closed, while 6.7% agreed, 6.7% was unsure and 10.0% did not answer this question.

While 15 participants indicated that they do store back-up fortification premix should the current stock become expired/damaged; only six participants provided information on where it was stored. Those who had back-up fortification premix, stored it in the fortification store (n = 1), in sealed containers (n = 2), in the bag store (n = 1), in a cool dry place (n = 1) and one company indicated that the fortification premixes are stored in two separate areas and explained that the likelihood that the fortification premixes could be compromised in both areas are highly unlikely.

Less than 50.0% (n = 13) of the participants reported that the temperature conditions of the stored fortification premix were monitored (Table 3.8). Only 11 provided information on how the temperature conditions were monitored. Five participants indicated that a thermometer is used, while others stored the fortification premix under cool and dry conditions (n = 3) and the rest indicated it is monitored by management (n = 1), or it was self-inspected (n = 1) or the temperature of the room was monitored (n = 1). In contrast, a high number of participants (n = 26; 86.6%) indicated that the expiry dates of the fortification premixes were monitored (Table 3.8).

Table 3.8: Practices regarding fortification premixes at the various mills (n = 30)

Variable	Number of mills	Total %
Fortification premixes purchased from different suppliers		
Supplier A[1]	9	30.0
Supplier B	4	13.3
Supplier C	1	3.3
Supplier D (Farmer)	1	3.3
Unsure	4	13.3
No information	2	6.7
Non-registered suppliers	9	30.0
Fortification premix storage		
Stored according to supplier/package instructions	19	63.3
Stored according to in-house procedures daily	5	16.7
Stored according to managers instructions	1	3.3
Stored in a cool room	1	3.3
No information	4	13.3
Presence of back-up fortification premix formulations at the mills		
Yes	15	50.0
No	12	40.0
No information	3	10.0
Monitoring of the temperature conditions of the stored fortification premixes		
Yes	13	43.3
No	14	46.7
No information	3	10.0
Monitoring of the expiry dates of the fortification premixes		
Yes	26	86.6
No	2	6.7
No information	2	6.7

[1]Fortification premix suppliers used by the mills were labelled alphabetically to ensure confidentiality

Forty percent of the participants (n = 12) indicated that the EHP have never visited the mill to monitor compliance with the fortification regulations. The other participants indicated that the EHP visited the mills every second year (n = 8; 26.7%), every six months (n = 5; 16.7%), once a year (n = 2; 6.7%), regularly (n = 1; 3.3%), every month (n = 1; 3.3%) and one (3.3%) participant indicated that the visits used to be every six weeks, but that it was irregular at the time the study was undertaken.

Only 43.3% of the mills conducted tests to determine whether the maize meal/wheat flour is fortified, fifty percent of the mills do not conduct tests, while the rest were unsure or did not provide any information.

Twenty three (76.7%) of the mills indicated that fortification is conducted by means of continuous mixing, two mills (6.7%) were unsure which method was used. The rest of the mills used two-stage mixing (6.7%), batch mixing (6.7%) and one mill (3.3%) employed both two-stage and continuous mixing at the same mill.

Thirteen mills (43.3%) did not provide any information when asked which test was used at the mill to determine whether maize meal/wheat flour was fortified. The rest (n = 7; 23.3%) provided other methods of determining whether the products were fortified (i.e. using an administrative log system), 10.0% used chemical analysis, 6.7% used the iron spot test and 6.7% indicated that no test was used whilst 10.0% were unsure.

3.4.12 Sources of information and training

Twenty three percent of the participants (n = 7) received information regarding food fortification from the DOH and about 16.7% (n = 5) received information from the NCM. Other information sources regarding food fortification were the supplier (n = 2; 6.7%), the NCM and SAGIS (n = 2; 6.7%), the DOH and internet (n = 2; 6.7%), in-house and internet (n = 2; 6.7%), SAGIS (n = 1; 3.3%), internet (n = 1; 3.3%), the DOH and NCM (n = 1; 3.3%) and the DOH and in-house (n = 1; 3.3%). One mill indicated the distributor, while another indicated a training company and the other indicated that no information regarding food fortification is received. Three mills (10.0%) did not provide information pertaining to this. The majority (n = 26; 86.7%) have not undergone any training regarding food fortification, while only three (10.0%) received training and of those two participants indicated that it was received from the technikon/NCM. One participant did not provide any information pertaining to this question. Areas of training received by the participants as indicated by only two participants included the types of malnutrition, the functions of vitamins, food and industrial safety and pest control.

3.5 Discussion

The purpose of this study was to determine the knowledge, attitudes and practices regarding food fortification among mill managers at maize meal and wheat flour mills in South Africa. Previous studies of a similar nature on the millers' level of knowledge of fortification have been conducted by the DOH[4] and MI.[8] Results of the DOH study is, however, of a confidential nature and not freely accessible[12] and the results obtained from the MI study were only used to compile a training manual for small millers.[8] To the principle researchers' knowledge, results of the above-mentioned studies have not been published in a public domain.

This study has certain limitations that need to be acknowledged. The response rate to this questionnaire study was low (n = 30; representing 14.2%) despite several attempts to increase participation. However, since the results of previous studies have not been made available, we believe that the present data will fill a gap and provide an indication of the present knowledge, attitudes and practices of the millers. Findings from this study could be used to improve the various information sources of food fortification used by mill managers, which will in turn improve their knowledge and may impact on their attitudes and practices.

In 2010, Louw, Troskie and Geyser[16] conducted a study among wheat millers and bakers, to identify growth barriers (factors that restrict or limit the development of the small wheat milling and baking industries) preventing development in rural areas. Originally their study was just limited to two provinces. As a result of the participants' unwillingness to share information, the investigators were obligated to venture outside of just those two provinces and this resulted in a final total of only 15 participants willing to be interviewed. This study confirmed the challenges experienced with obtaining a satisfactory response rate as also demonstrated in our study.

In 2006, the MI and the National Fortification Alliance of South Africa embarked on a survey to identify small and medium-sized mills in six of the nine provinces to determine the miller's knowledge level about fortification and compliance with fortification regulations.[8] In our study the overall mean knowledge score for participants was 52.2% (average) and more than 75.0% of the mills knew that food fortification is not the only method of addressing micronutrient deficiencies. A low percentage (10.0%) of participants in this study received training on food fortification; their average knowledge indicates that millers have not obtained sufficient knowledge from the manual collated for them. The level of education showed to have no impact on the knowledge of millers.

Only 50% of the maize meal managers knew which vitamins are added to maize meal which reflects average knowledge. Nineteen of the managers did not know which vitamins are added to white bread flour and surprisingly two of those were managers of wheat mills.

Whilst participants had a positive attitude towards the time and work required to implement food fortification, they did, however, have a negative attitude towards the financial investment needed as they felt that food fortification costs the mill a lot of money and the fortification premix is too expensive. According to the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), manufacturers of maize meal and wheat flour must purchase the fortification premix from suppliers that have been registered with the DOH.[5] This list is updated when registration of a fortification premix manufacturer/supplier/importer is approved.[17] Fortification premixes are calculated to be approximately R30 per ton which translates to a one cent increase in a loaf of bread and two cents in a kilogram of maize meal.[3]

A large percentage of mills (76.7%) used the continuous mixing method as a method to fortify maize meal or bread flour. Continuous mixing can either be conducted manually or automatically. If it is done manually, the fortification premix is added by weight or volumetric measure to a known volume of grain prior to milling.[8] If it is done automatically; a precision micro-ingredient powder feeder is attached to the mill and dispenses an amount of fortification premix proportional to the meal/flour. This is a more cost-effective and precise method. Unfortunately no information was collected on the type of continuous mixing method used at the mills. About 46.7% (n = 14) of the participants regarded food fortification as a time consuming activity, while 50.0% (n = 15) were not of this opinion and one participant provided no response to this question. Those participants (n = 15; 50.0%) who were not of the opinion that food fortification is a time consuming activity, 13 indicated that they used continuous mixing at the mills, while one mill used a combination of two stage mixing plus continuous mixing while the other was unsure. Of those 14 participants who indicated that it is a time consuming activity, 71.4% (n = 10) used continuous, two-stage (n = 2) and batch mixing (n = 2) was used by the rest.

Despite the fact that the majority (n = 23; 76.7%) of the mills used continuous mixing, a low cost method, 15 (eight medium sized, five large and two small sized) of those mills indicated that food fortification is expensive and the money could have been spent elsewhere. The Department of Trade and Industry, together with the DOH, created an incentive scheme to subsidise expenses at mills. Small, medium and large mills receive 100%, 75% and 50% re-imbursements respectively for purchasing and installation of food fortification equipment.[3] It was therefore interesting that mills who used continuous mixing, mainly medium scale mills, who qualifies for a 75% reimbursement would state that food fortification costs their mill a lot. No investigation was made whether the mills already received a subsidy from the government, a recommendation can be made to investigate whether they have received it to make millers more aware of the fact that they are eligible for subsidies and this could possibly alleviate their expenses. To qualify for the incentive millers are required by law to be registered with SAGIS and must be in possession of a tax certificate.[18] Alternatively, if they were already receiving subsidies, further investigation is required to ascertain why those mills agreed with the statement that “food fortification is expensive”.

The fortification regulations under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972)[5], stipulated that certain steps must be taken by manufacturers to fortify maize meal and white and brown bread flour. These steps included: purchasing blending equipment/feeders/scales, purchasing fortification premixes from registered DOH suppliers, storing premixes away from direct sunlight/heat, adhering to strict stock rotation to prevent stock from losing potency and comply with the shelf life expiry date, checking of fortification premix feeders once per shift, performing visual checks twice per shift to ensure that fortification premixes have been used and performing regular iron spot tests on the maize meal and flour.[3] It was encouraging to note that 86.7% of the mills indicated that they have modified their milling enterprises to comply with the expected regulations.

Each mill manager indicated from which manufacturers/suppliers/importer/distributor the fortification premix was obtained. Taking into account both 2011 and 2012 registered suppliers (as registration is only valid for one year) and the date at which each questionnaire was completed, of the 24 mills indicating a supplier, only 58.3% (n = 14) mills were using registered suppliers.[17] Using non-registered suppliers may result in using incorrectly formulated fortification premixes and ultimately affects the nutrient content of the finished product (maize meal and flour).[19]

Although 60.0% of mills were visited by the EHP, forty percent of the participants (one small mill, three medium mills and eight large mills) indicated that the EHP has never visited the mill to monitor whether the mill complied with the fortification regulations. These EHP have the mandate to carry out routine monitoring of mills to ensure compliance with food fortification regulations. Findings of a study conducted by Yusufali, Sunley, De Hoop and Panagides to estimate the nutrient content (vitamin A and nicotinamide) of maize meal at retail level concluded that addition of fortification premix at the mills is insufficient and more regular visits by the EHP are needed.[19]

In a report by the DOH one of the issues while dealing with the milling industry was the complexity of finding small millers throughout rural areas due to their remoteness.[3] Although one of the small mills, located in a rural area, indicated that the EHP have never visited the mill, the sample size of this group (n = 3) was too small to draw any conclusions. All the mills that were never visited by the EHP operated for more than 200 days a year and represented one small, three medium and eight large sized mills. These small and medium-sized mills scored lower (62.2%) than the large (70.2%) sized mills for practices at the mill. Monitoring by EHP could contribute to making an improvement in successful food fortification practices at the respective mills by collecting samples of fortified products for analysis.

A shortcoming of the small and medium sized mills was the lack of testing the final products to determine whether it was fortified. In addition two of the medium sized mills incorrectly answered a question that the fortification premix can be stored anywhere as long as the packet is closed. In a study conducted over a period of a year, vitamin A stability in a premix was investigated at various intervals. At the beginning of the study, three months, six months and 12 months later, the vitamin A levels in the premix was 16 200 IU/g, 11 500 IU/g, 8 700 IU/g and 6 300 IU/g respectively. The storage conditions during this time remained constant at 25°C at a relative humidity of 60.0%.[20] Since vitamins are sensitive to light and can become oxidized very quickly[15], the fortification premix was stored in paper bags in the dark.[20] The responsibility regarding storage of the fortification premixes at the mills lies with the manufacturer.[3] Findings of a study conducted by Yusufali, Sunley, De Hoop and Panagides to estimate the nutrient content (vitamin A, iron and nicotinamide) of maize meal at retail level concluded that insufficient addition of fortification premix at the mills was responsible for the low vitamin A values.[19]

While the majority (n = 26; 86.7%) of the mills have implemented changes, to accommodate food fortification at their respective mills, 10% have not. Training that is easily accessible might encourage those still not on board to also comply with the food fortification legislation.

This study shows that mill managers have average knowledge regarding food fortification and that not all have implemented food fortification at the mills. Whilst participants had a positive attitude towards the time and work required to implement food fortification, they did however have a negative attitude towards expenses as they felt that food fortification costs the mill a lot of money and the fortification premix is too expensive. On a positive note they welcomed the visits by EHP at the mills. Emphasis should be placed on the importance of fortification equipment to dispense fortification premix. Additionally millers should be made aware of the training manual which could enhance the millers' compliance to the legislation. The training manual is concise, easy to read and understand and provides step-by-step instructions.[8]

3.6 Limitations of the study

Despite several efforts to increase the response rate it was low with the result that the sample size of this study is small. In our study questionnaires were distributed via email, post and fax. The obvious advantages of using email, post and fax as a method of distribution (as opposed to physically visiting the mills) include the low cost and reaching all intended geographical areas.[21] Additionally, this combination was indeed employed as participants indicated their preference upon the first contact made with them. At the onset of the study, the use of online questionnaires was considered; however, it was decided against to save the participants the internet costs. A meta-analysis of 35 questionnaire surveys between 1992-2005 using electronic data collection yielded a lower response rate than with paper surveys.[22] This was attributed to a number of Information Technology-related problems, such as incompatibility of different monitors, questionnaires and programs, slow/interrupted internet connections and the technical problems with computers.[23] The above was taken into account at the onset when a decision was made (in consultation with the MRC Web and Media Technologies Platform Manager) not to use an online survey.

In a comparison study of mail, fax and web-based survey methods a response rate of 26%, 17% and 44% respectively was achieved.[24] In this study a collective response rate of 14% was achieved of which 23% were returned by mail/post, 33% by fax and 43% by email. In a study whereby questionnaires were emailed to 1 717 registered dietitians in California, an identical response rate of 14.7% was achieved.[25] Collection of data may be improved with the use of telephone interviews or face-to-face interviews. The cost implications of using either method for a national study, however, could be substantial.[26] Sibbald, Addington-Hall, Brenneman and Freeling found that the postal response rate of 52% was increased to 82% by conducting telephone interviews with non-respondents.[26] In this study, whilst interviews were not telephonically conducted with non-respondents, reminder telephone calls were made and this increased the response rate from 10.0% to 14.2%. Although the study consisted of a very small sample and might thus not be representative it reports on important information regarding the present knowledge, attitudes and practices of those responsible for food fortification at the mills.

Another limitation of the study was that data collection took place over a short period of time (October-December 2011; March-April 2012), which did not take into account the harvest season. It is recommended that data collection in this type of study should take place during harvest times of wheat and maize respectively (November/December[27]; May-August[28]). This strategy could ensure that more mills, especially the smaller sized mills, which are only operational during harvest times and closed the rest of the year, could also be reached and included in the study. Since larger sized mills are operational throughout the year, they were contactable and therefore the study included a greater number of larger sized mills which is less representative of the total population.
Conducting research within the maize meal and wheat flour industry proved to be difficult. This can be attributed to the following factors e.g. the seasonality by which some of the millers operate, the refusal of bigger companies to participate in the study and share their information even though ensuring confidentiality was explicitly expressed to them and the duration of time lapsed from the first contact made with the millers to the actual date the questionnaires were distributed to the millers.

3.7 Conclusion

Participants had an average level of knowledge with regards to food fortification. In addition, there were still shortcomings regarding food fortification practices among small and medium sized mills, which this study highlighted. Despite the small sample size in this study, knowledge was marginally or significantly higher for those who had positive attitudes towards food fortification. This suggested that for food fortification to be successful, improving the knowledge base of mill managers could possibly contribute to successful food fortification at the mills.

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Chapter 4

The contribution of maize meal to the micronutrient intake of a national sample of South African adults aged 16-88 years old[b]

Danster-Christians N, Burger H-M, Daniels L, Laubscher R, Wolmarans P.

4.1 Abstract

Objective: The aim of this study was to determine the contribution of maize meal to the micronutrient intake of South African adults, aged 16-88 years old.

Design: Descriptive cross-sectional study.

Setting: All nine provinces of South Africa.

Participants: South African adults 16-88 years old who reported maize, rice or flour intake (n = 2 809) as part of a national consumer survey.

Methods: Data were collected by means of a short quantified food frequency questionnaire focussing on maize intake. Additional demographic data were also assessed. The macro-and-micronutrient intake of maize meal consumers was determined using the South African Food Composition Database. Nutrient intake was compared to the Dietary Reference Intakes values for the various age and gender groups.

Results: In this study, 84% (n = 2 356) of the total consumer survey population were maize meal consumers. The average portion of cooked maize meal consumed per day (of those who indicated their age, n = 2 344) was 585 g (SD = 543 g) and it contributed up to 75% of the Recommended Dietary Allowance for carbohydrate. The median intake was at least 50% of the Estimated Average Requirement (EAR) for thiamine, folate and iron. For vitamin A, riboflavin, niacin, vitamin B_6 and zinc, the median intakes were 25%, 20%, 46%, 45%, and 34% of the EAR respectively for the consumers. The mean portion sizes of maize meal consumed by the unemployed and employed maize meal consumers were 696 g (SD = 504 g) and 564 g (SD = 519 g) respectively. Maize meal intakes of the unemployed maize meal consumers were significantly ($p<0.001$) higher than those of the employed maize meal consumers and therefore, the intakes of the micronutrients forming part of the national food fortification programme were significantly higher in the former. For household income (HHI) categories earning above R6 000 per month the zinc, vitamin A, vitamin B_6, thiamine, niacin, riboflavin, iron and folate intakes were significantly lower than HHI categories earning below the poverty line of R2 000 per month.

Conclusion: In this study maize meal was an important food item in the diets of the participants. This study highlighted that unemployed and lower HHI groups consumed more maize meal than those who were employed or were from higher HHI groups. In these groups, which could be vulnerable to micronutrient deficiencies the food fortification programme plays an important role in providing essential micronutrients.

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[b] *Article to be submitted to the South African Journal of Clinical Nutrition*

4.2 Introduction

In 2002, the World Health Organization estimated that globally, two billion people suffer from vitamin and mineral deficiencies. These deficiencies are commonplace in both developing and developed countries. Among these, iodine, iron, vitamin A and zinc micronutrient deficiencies are most prevalent.[1]

The 1993 - 2005 WHO Global Database on Anaemia report indicated that in the United States of America, United Kingdom, Canada and Australia the proportion of non-pregnant females of reproductive age with anemia (Hb <120 g/L) was 6.9%, 8.8%, 14.3% and 14.7% respectively, whilst figures for Brazil, Indonesia, Philippines and India were 23.1%, 33.1%, 42.1% and 52.0% respectively. Of the above-mentioned countries all practiced mandatory food fortification with the exception of India practicing voluntary fortification.[2] Although people in all population groups in all regions of the world may be affected by micronutrient deficiencies, the most widespread and severe problems are usually found amongst resource poor, food insecure and vulnerable households in developing countries.[3] In 1993, the South African Vitamin A Consultative Group (SAVACG) was formed, and given the paucity of national data, was mandated to collect information on the anthropometric and micronutrient status of children younger than six years of age. Findings of the study conducted by the SAVACG in 1994 indicated that the prevalence of anaemia was 21% (Hb <11 g/dL).[4]

The SAVACG study also found that nationally 33.3% of pre-school children were vitamin A deficient and had a marginal vitamin A status (serum retinol concentration <20 µg/dL). In the Northern Cape province, the prevalence was the lowest at 18.5%, whilst in the Limpopo province it was highest at 43.5%.[4]

The 1999 National Food Consumption Survey (NFCS) conducted amongst 1-9 year old South African children showed that the mean intake of zinc was inadequate in all age groups and in all provinces. Nationally 52-69% of children had an intake of less than 50% of the Recommended Dietary Allowance (RDA).[5] In 2004, the steering committee of the International Zinc Nutrition Consultative Group compiled a technical document in which the current knowledge of zinc and health-related aspects of zinc nutrition were discussed. As indicated in the report, the proportion of the population at risk of inadequate zinc intake, based on data derived from national food supplies, was estimated at 4.2% and 9.1% for the developed countries France and Italy respectively. In developing countries like Peru and Thailand it was estimated at 41.6% for both countries and 43.4% for Zimbabwe while, in South Africa it was estimated at 19.7%.[6] The 2005 National Food Consumption Survey - Fortification Baseline showed that for the 1-9 year old children in South

Africa, the mean serum zinc concentration was 68.7 µg/dL (normal value is 65 µg/dL), while 45.3% were zinc deficient.[7]

Anaemia, low birth weight and reduced learning and working capacity occur as a result of iron deficiency. A lack of vitamin A can result in night blindness and xerophthalmia, whereas the consequences of zinc deficiencies include impaired growth and decreased resistance to infectious diseases. Cognitive impairment, goitre and hypothyroidism are among the major deficiency disorders linked to iodine deficiency.[8]

Vitamin and mineral deficiencies are silent epidemics affecting people of all genders and ages, as well as specific risk groups, e.g. the elderly, pregnant females and young children.[8] Improving the intake of micronutrients involves many approaches around the world including micronutrient supplementation programmes, fortification of staple foods, dietary diversification, modification of traditional diets and other public health measures (e.g. control of parasites and infections).[9]

The implementation of food fortification programmes brings forth the opportunity to reach many people and increase their intake of several micronutrients unintentionally. In addition, it offers a sustainable and economical source of the micronutrients.[10]

The fortified foods must be consumed in adequate amounts by all those in the population who need the additional micronutrients and this is often not the case, because poorer and undernourished segments of the population are more likely to produce their own food and purchase fewer fortified products.[10] The nutrient intakes of South African children (1-9 years old), determined as part of the 1999 NFCS, showed that the intakes of energy, calcium, iron, zinc, selenium, vitamins A, D, C and E, riboflavin, niacin, vitamin B_6 and folic acid were below two-thirds of the RDA.[5]

Mandatory fortification of South Africa's main grains, maize meal and wheat flour (bread), became effective in October 2003 under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972).[11] The findings from the NFCS, 1999, identified maize meal, sugar, tea, whole milk and brown bread as the five most commonly eaten foods.[5] A decision was made by the South African government to use maize meal and wheat flour (bread) as the food vehicles for the food fortification programme as it was shown to be the most commonly consumed staple food.[5] The regulations stipulated that all maize meal and white and brown bread flour milled in South Africa must contain specified amounts of vitamin A, thiamine, riboflavin, niacin, folic acid, vitamin B_6, iron and zinc to contribute to the intake of essential micronutrients.[11]

Since 2003, a reputable South African manufacturing company has been conducting research among end consumers of grain products (maize, rice, flour) to obtain data on consumers' awareness, consumption and attitude towards various brands of grain-based products. As part of the study conducted in 2011, a maize-based short quantified food frequency questionnaire (SQFFQ), was added to the questionnaire and portion size photos of maize food items and maize dishes were also added for quantification purposes. This was done to obtain information on usual intakes of maize. The data on maize meal intakes of South Africans collected as part of the national consumer survey[12] provided an opportunity to do secondary analysis on the data.

The main aim of this study (secondary analysis of the data) was to assess the contribution of fortified maize meal to the micronutrient intake (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc) of a national sample of South Africans aged 16-88 years old, since these nutrients form part of the national food fortification programme.

4.3 METHODS

4.3.1 Study design

National consumer surveys have been conducted by a South African leading grain-based manufacturing company for more than a decade. The survey used for the purposes of this study took place from March to May 2011 and the aim of the survey was to assess consumers' awareness, consumption and attitudes towards various brands of maize meal, rice and flour products. This survey had a cross-sectional study design and the data were collected by an independent research company specialising in qualitative and quantitative research.[13]

In addition to the structured consumer questionnaire utilised during the consumer survey, an SQFFQ which also included portion size photos of maize food items, maize meal based dishes and maize meal beverages, developed by Dr Martani Lombard[c], was used in the 2011 survey for the collection of quantitative information on usual maize intakes. The study population, sampling procedures, methods and provincial representative weighting have been described in detail[12]; however, a brief summary is given here.

The data collected on the maize meal intakes of a national sample of adult South Africans will be used for the purposes of this chapter to assess the contribution of maize meal to the micronutrient intake (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc).

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4.3.2 Study population

A sample size of 3 000 households was selected using the 2001 Census household data.[14] South African adults from the different ethnic groups within the nine provinces consuming two of the following categories of grains, i.e. maize, flour or rice products were eligible to participate (Table 4.1). Each household had an equal chance of being selected to participate in the survey. The survey population comprised males and females aged 16 to 88 years old.

Table 4.1: Percentages* of study population by province and ethnic group

Province	Black African %	Mixed ancestry %	Indian South Africans %	Caucasian %	Total %
Eastern Cape	11.6	1.0	0.0	0.9	**13.5**
KwaZulu-Natal	15.1	0.3	1.8	1.5	**18.7**
Northern Cape	0.7	0.8	0.0	0.3	**1.8**
Western Cape	2.8	4.8	0.1	2.7	**10.4**
Free State	5.7	0.2	0.0	0.7	**6.6**
Gauteng	17.4	0.7	0.5	5.1	**23.7**
Limpopo	10.2	0.0	0.0	0.3	**10.5**
Mpumalanga	6.0	0.0	0.0	0.5	**6.5**
North West	7.6	0.1	0.0	0.6	**8.3**
Total	**77.1**	**7.9**	**2.4**	**12.6**	**100.0**

*Percentages based on 2001 Census household data[14]

4.3.3 Socio-demographic information

Demographic information such as ethnic group, age, gender, residential province, household income (HHI), employment and education, was collected by the independent research company as part of the structured consumer questionnaire developed by the grain company. This questionnaire was piloted before commencement of the study interview. Participants were asked a series of questions on awareness and consumption of as well as attitudes towards various brands of maize, rice or flour products. The questionnaire was segmented into three main product categories, namely maize, rice and flour questions. Participants were expected to answer two of the three main sections, while general questions were compulsory for all. Interviewers followed a predetermined procedure to determine which two of the three main sections to probe. Each interview took between 20 to 30 minutes to complete the questionnaire.

4.3.4 Dietary data collected using a short quantified food frequency questionnaire

4.3.4.1 Short quantified food frequency questionnaire (SQFFQ)

Dietary data were collected by means of a SQFFQ. To develop the questionnaire data were obtained from the literature, a review of 24-hour recalls and focus group discussions among 56 rural isiXhosa speaking females from the Eastern Cape (EC).[15] The review process of the 24-hour recalls involved checking data from a survey previously conducted among the population using single 24-hour recalls (n = 159).[16] The objective of the review of the recalls was to identify commonly consumed food items and dishes, as well as food preparation methods. From this, a draft SQFFQ was developed which was then tested by means of in-depth interviews and focus group discussions to finalise the SQFFQ.[15]

The 21 maize-based food items questions in the SQFFQ represented commonly consumed food items of isiXhosa speaking people residing in five rural villages stretching over two rural areas (Centane and Bizana) of the EC. For the purposes of the national consumer survey, the SQFFQ utilised in the EC was amended to reflect maize-based food items commonly consumed within a Western/urban setting. As a result, 11 maize-based food items/dishes/beverages were excluded: baked bread, steamed bread, dumplings, vetkoek, maize meal plus imifino, maize meal plus beans, soup (maize kernels plus dried sugar beans), mealie rice plus imifino, mealie rice plus spinach, mealie rice plus pumpkin and amasi. Six more dishes were added including sour porridge, fermented maize meal and maize meal plus vinegar, samp, maize rice, samp plus peanuts and creamed sweetcorn. As part of the national consumer survey, the SQFFQ therefore included 16 maize-based food items/dishes/beverages questions (Addendum 8) as a data collection tool. These questions investigated the intake of 16 maize-based products that included stiff porridge, soft porridge, crumbly porridge, fermented maize and vinegar, fermented maize, white samp, samp and beans, samp and peanuts, maize rice, maize meal with pumpkin, maize meal with cabbage and spinach, corn on the cob, creamed sweetcorn, canned whole kernel corn, mageu and traditional beer.

Fifty professional interviewers were trained on how to complete the SQFFQ and to obtain the weight of each participant. Body weights of participants were measured using non-digital bathroom scales. Training on how to complete the SQFFQ was conducted by Dr Martani Lombard[d] and training on weighing the participants by Dr Hester-Mari Burger[e]. Information on habitual maize intakes and body weights were collected for each participant after informed and signed consent was obtained (Addendum 9). Food photographs of various maize-based dishes (stiff-, soft- and crumbly porridge, samp, combined dishes such as samp and beans, spinach and maize meal, pumpkin and maize meal, and non-alcoholic maize meal fermented beverage mageu) of three different portion sizes were developed[17] and used alongside the EC SQFFQ to determine the portion sizes consumed. The food photographs were developed by Dr Martani Lombard as part of her doctoral thesis.[18] The first draft of the food photo series was evaluated by two research dietitians and a research nutritionist, whilst the second draft of the food photo series was evaluated by means of focus group discussions in the two rural areas of the EC selected for her doctoral

[d] Previously from the University of Stellenbosch and currently at the North-West University
[e] Previously from the Medical Research Council and currently at the Cape Peninsula University of Technology

study.[17] Various factors were taken into consideration upon development of the food photographs namely; colour of the plate, type of plate used, background colour of the photograph and scale. After two drafts, the final food photograph series was developed. The final food photograph series included 63 photos for the study conducted in the EC. This comprised 21 maize-based food items (single ingredient food items, combined food dishes and beverages) characterised by photographs portraying three different sizes (small, medium and large) of each dish. All the maize-based food dishes were dished into flat light blue enamel plates and photographed using a black background. Using a black background ensured that food items white in colour displayed sufficiently. The sizes of the food photographs represented life-size images of the dishes to assist with correct identification of the portion sizes. For the purposes of the national consumer survey, the photograph series were extended to four sized photographs of each dish to include an extra-large portion size. Coding (e.g. portion sizes relevant to the photograph) on the reverse side of the photographs corresponded with that on the SQFFQ in order to shorten the dietary interview process and allow easy identification of the relevant portion size of a food that was consumed within the reference reporting period.

The SQFFQ was designed to measure the intake during the past month. The sequence of questions on the SQFFQ was as follows: name of maize meal dish; quantity (g/mL); times per day; days per week (0 - 7), times per month (0 - 4) and seldom/never. To analyse the data for macronutrient and micronutrient intake, the data were converted into the amount of food 'consumed per day' as illustrated below:

Per day: Amount consumed per day	= (portion (g) X number of times per day X 28)/28
Per week: Amount consumed per day	= (portion (g) X number of days per week X 4)/28
Per month: Amount consumed per day	= (portion (g) X number of times per month)/28

The maize meal intake data collected by the independent research company were captured electronically in Microsoft Excel version 2003 by a junior dietitian.

For the purpose of secondary analysis the principle researcher of this study verified whether the maize and maize meal intake data captured by the junior dietitian were multiplied (per day/per week/per month) correctly to obtain the amount consumed per day for each of the participants. This was done by ensuring that the correct portion sizes (Addendum 10) were captured as indicated by all participants (n = 2 809), including those who consumed maize meal (n = 2 356) and all participants who consumed maize-based items (n = 453). In addition, the body weight as recorded on the questionnaire of each of the participants was also verified against the original SQFFQ of each participant by the principal researcher.

The maize meal portion of each combined dish (maize meal porridge and pumpkin; maize meal porridge and spinach and cabbage) was calculated by the principal researcher. Where mixed dishes were applicable, ratios of 1:2 (for one maize meal and one vegetable ingredient) or 1:1:1 (for one maize meal plus two vegetable ingredients) were selected based on the recipes developed for the Ratio and Portion size photo (RAPP) tool.[19] The total contribution of maize meal based beverages (i.e. mageu and traditional beer) was also calculated separately.

4.3.5 Data analysis

Mandatory fortification of South Africa's main grains, maize meal and wheat flour (bread) became effective in October 2003.[11] To this end, only the total maize meal intakes were used to determine the energy, macronutrient (total protein, total fat, available carbohydrate and dietary fibre) and micronutrient intake (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc) of each participant in the secondary analysis of the data. To determine the energy and nutrient intake contributed by fortified super soft, stiff and crumbly maize meal porridges with moisture contents of 86.7 g, 70.7 g and 49.7 g per 100 g respectively, the 2010 updated food composition database in the South African Food Data System (SAFOODS) was used.[20] To demonstrate the changes in micronutrient intakes as a result of food fortification, nutrient intake analyses were conducted in Microsoft Excel with unfortified and fortified super maize meal porridges and the statistical program, SAS version 9.3, was used to determine the difference between the two values. Chemically analysed values were available for both unfortified and fortified maize meal porridges and these values were used for this purpose.[21]

Using Microsoft Excel version 2003, the macro-and-micronutrient intakes were expressed as a percentage of the Estimated Average Requirement (EAR)[22,23], the Recommended Dietary Allowance (RDA)[24], the Estimated Energy Requirement (EER)[24] or the Adequate Intake (AI)[24] for those maize meal consumers who indicated their age (n = 2 344). There is no RDA for energy therefore the EER was used, the RDA was used for protein and available carbohydrate[f] and the AI for dietary fibre[24]. An AI is set for a nutrient when there is insufficient evidence to determine an EAR and RDA. Neither an AI nor RDA has been set for total fat.[24] The contributions of total carbohydrate (available carbohydrate plus dietary fibre)[25], protein and fat to total energy intakes were expressed as percentages of the energy intake values and compared to the Acceptable Macronutrient Distribution Ranges (AMDR). To determine the energy distribution (percentage) of protein, total carbohydrate (available carbohydrate plus dietary fibre) and fat stratified by gender, the EER for a male and female, 12 881 kJ and 10 093 kJ respectively, were chosen. The EER for

[f] Available carbohydrate (defined as the sum of the free sugars, dextrins, starch and glycogen)[25] expressed as a percentage of the RDA and defined as total carbohydrate (starches and sugars) in the DRI report.[24]

individuals aged 19 up until 70 years of age is the same.[24] Since the number of individuals in the 14 - 18 year age group were only 38, the same EER of the 19 - 70 year old individuals was applied to the 14 - 18 year old individuals, only for the purposes of determining the energy distribution in this study.

Micronutrient intakes were determined and expressed as a percentage of the Dietary Reference Intakes (DRIs). Vitamin A consists of retinol from animal sources and provitamin A carotenoids (β-Carotene, α-carotene and β-cryptoxanthin) from plant sources. The values for vitamin A intake in the food composition database of SAFOODS are expressed as microgram Retinol Equivalents (µg RE).[25] β-Carotene values are divided by 6 and α-carotene and β-cryptoxanthin values are divided by 12 to convert their vitamin A activity to µg RE.[26] More recent absorption and bioconversion data now recommends that provitamin A activity in foods be expressed as RAE[22], which is 50% of the corresponding RE. Twelve µg β-carotene from a mixed diet instead of 6 µg β-carotene, therefore converts to 1 µg RAE and 24 µg α-carotene instead of 12 converts to 1 µg RAE.[22] In the DRI report, the units for vitamin A intakes are reflected as RAE and therefore cannot be compared to the values in SAFOODS. Plant sources of vitamin A expressed in RE in the SAFOODS therefore need to be divided by two to obtain the value in RAE.[20] Naturally maize meal does not contain vitamin A and the form of vitamin A fortificant used to fortify maize meal, as part of the South African food fortification programme, is vitamin A palmitate, which is retinol. Since one µg of retinol is equal to one µg RAE, it will not have any implications for this study when the vitamin A intakes are compared to the DRIs.

The Biostatistics Unit at the Medical Research Council (MRC) assisted with statistical analysis using the SAS version 9.3 statistical program. Continuous data were expressed as means (SD) or medians (interquartile range), (IQR1; IQR3) and categorical data as percentages. Since the data were not normally distributed, non-parametric tests were used. The Wilcoxon signed-rank test was used to test for differences between mean values for unfortified and fortified maize meal consumed by the gender groups. The Pearson’s chi-square test was used to assess the gender differences of formally employed versus unemployed participants. For the purposes of this study, self-employment was regarded as working in the informal sector and not categorised with the formally employed.[27]

To determine the distribution of HHI categories in the nine provinces above and below the poverty line[28] for the maize meal consumers the average number of people per household was assumed to be four based on the 2003 Demographic and Health Survey quotient.[29] Utilising the upper-bound poverty line of R577 per capita for South Africa, the HHI per month was calculated. The cut-off for HHI below the poverty line was set at R2 000 per month for a household of four individuals. To test for differences in intakes of fortified maize meal between HHI categories above the poverty line compared to HHI categories below the poverty line, a generalised linear model was applied.

It is recommended that maize meal is fortified with six vitamins and two minerals to provide individuals with 31% vitamin A, 25% thiamine, 17% riboflavin, 25% niacin, 25% vitamin B6, 50% folic acid, 50% iron and 20% zinc of the RDA.[11] To determine whether the micronutrient intake of participants met these recommendations, the fortified maize meal intakes of each individual was analysed, expressed as a percentage of the relevant RDA[22,23] (according to age and gender) for the gender groups and then compared to the DOH recommendations.[11]

To test for differences in intake of fortified maize meal between the unemployed and the employed regarding vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc, the Wilcoxon rank sum test was used. P-values below <0.05 were considered statistically significant.

4.3.6 Ethical approval

Ethical approval was obtained from The Health Research Ethics Committee of the Faculty of Health Sciences, Stellenbosch University (Addendum 6: Ethics reference number N10/11/374 and Addendum 11: Ethics reference number N13/03/042) and from the MRC Ethics Committee (Addendum 7: Protocol ID EC11-004). Permission to use the data from the national consumer survey was also obtained from Dr Martani Lombard (North-West University) and Dr Hester-Mari Burger (Cape Peninsula University of Technology).

4.4. Results

4.4.1 Characteristics of the study population

The study population consisted of 2 809 individuals (referred to as ‘total population’) of which 2 356 (83.9%) were maize meal consumers and 453 (16.1%) non-consumers of maize meal. The characteristics of the consumers of maize meal, non-consumers of maize meal and total population are displayed in Table 4.2.

Table 4.2: Characteristics of maize meal consumers (n = 2 356), non-consumers of maize meal (n = 453) and the total population (n = 2 809)

Variable	Maize meal consumers (n = 2 356)	Non-consumers of maize meal (n = 453)	Total population (n = 2 809)
	n (%)	n (%)	n (%)
Gender			
Male	663 (28.1)	119 (26.3)	782 (27.8)
Female	1 693 (71.9)	334 (73.7)	2 027 (72.2)
Ethnic group			
Black African	1 698 (72.1)	73 (16.1)	1 771 (63.0)

Table 4.2 (contd): Characteristics of maize meal consumers (n = 2 356), non-consumers of maize meal (n = 453) and the total population (n = 2 809)

Variable	Maize meal consumers (n = 2 356)	Non-consumers of maize meal (n = 453)	Total population (n = 2 809)
	n (%)	n (%)	n (%)
Mixed ancestry	336 (14.3)	73 (16.1)	409 (14.6)
Caucasian	255 (10.8)	250 (55.2)	505 (18.0)
Indian South Africans	67 (2.8)	57 (12.6)	124 (4.4)
Age category (years)			
14 - 18	38 (1.6)	3 (0.7)	41 (1.5)
19 - 30	1 084 (46.0)	169 (37.3)	1 253 (44.6)
31 - 50	1 012 (43.0)	238 (52.5)	1 250 (44.5)
51 - 70	189 (8.0)	29 (6.4)	218 (7.8)
71+	21 (0.9)	1 (0.2)	22 (0.8)
No information	12 (0.5)	13 (2.9)	25 (0.9)
Household Income* category			
R500 and less	14 (0.6)	1 (0.2)	15 (0.5)
R501 - R1 000	37 (1.6)	12 (2.6)	49 (1.7)
R1 001 - R2 000	144 (6.1)	7 (1.5)	151 (5.4)
R2 001 - R4 000	326 (13.8)	24 (5.3)	350 (12.5)
R4 001 - R6 000	365 (15.5)	25 (5.5)	390 (13.9)
R6 001 - R8 000	325 (13.8)	51 (11.3)	376 (13.4)
R8 001 - R10 000	256 (10.9)	54 (11.9)	310 (11.0)
Over R10 000	157 (6.7)	97 (21.4)	254 (9.0)
Not disclosed	732 (31.1)	182 (40.2)	914 (32.5)
Employment status			
Self-employment	202 (8.6)	60 (13.2)	262 (9.3)
Employed	1 546 (65.6)	305 (67.3)	1 851 (65.9)
Unemployed/looking for work	212 (9.0)	19 (4.2)	231 (8.2)
Student	151 (6.4)	27 (6.0)	178 (6.3)
Housewife	123 (5.2)	24 (5.3)	147 (5.2)
Pensioner/retired	104 (4.4)	12 (2.6)	116 (4.1)
No information	18 (0.8)	6 (1.3)	24 (0.9)
Education			
No schooling	12 (0.5)	1 (0.2)	13 (0.5)
Sub A - Std 2/Grade 1 - 4	19 (0.8)	2 (0.4)	21 (0.7)
Std 3 - Std 5/Grade 5 - 7	66 (2.8)	10 (2.2)	76 (2.7)
Std 6 - Std 8/Grade 8 - 10/NTC	208 (8.8)	14 (3.1)	222 (7.9)
Std 9/Grade 11/NTC 2	303 (12.9)	28 (6.2)	331 (11.8)
Std 10/Grade 12/NTC 3	1 102 (46.8)	160 (35.3)	1 262 (44.9)
Technikon/University	640 (27.2)	237 (52.3)	877 (31.2)
No information	6 (0.3)	1 (0.2)	7 (0.2)
Province			
Eastern Cape	302 (12.8)	50 (11.0)	352 (12.5)
Free State	175 (7.4)	14 (3.1)	189 (6.7)
Gauteng	562 (23.9)	75 (16.6)	637 (22.7)
KwaZulu-Natal	313 (13.3)	92 (20.3)	405 (14.4)
Northern Cape	120 (5.1)	24 (5.3)	144 (5.1)
North West	198 (8.4)	44 (9.7)	242 (8.6)
Western Cape	196 (8.3)	106 (23.4)	302 (10.8)
Limpopo	314 (13.3)	32 (7.1)	346 (12.3)
Mpumalanga	176 (7.5)	16 (3.5)	192 (6.8)

*Household income per month

In the consumers group, males and females comprised 28.1% (n = 663) and 71.9% (n = 1 693) respectively, whilst in the total population, the gender distribution was, 27.8% (n = 782) males and 72.2% (n = 2 027) females.

Seventy two percent (n = 1 698) of the black African ethnic group consumed maize meal. Only 14.3% (n = 336) of South Africans of mixed ancestry ('coloureds') consumed maize meal compared to 10.8% (n = 255) of the Caucascian (white) population group and 2.8% (n = 67) of Indian South Africans. The highest proportion (n = 250; 55.2%) of the non-consumers of maize meal came from the white population group.

Information on age was not available for 0.5% (n = 12) of the maize meal consumers. As a result the nutrient intakes were expressed as a percentage of the EER, RDA, AI or EAR[22,23,24] for only those who indicated their age. For participants 14 - 18 years of age, 38 (1.6%) individuals consumed maize meal. The highest number of individuals (n = 1 084; 46.0%) consuming maize meal was in the 19 - 30 years age category, followed by 1 012 (43.0%) individuals in the 31 - 50 years age category. The highest number of non-consumers of maize meal (n = 238; 52.5%) was in the 31 - 50 years age category.

A third of the maize meal consumers (n = 732; 31.1%) and total population (n = 914; 32.5%) did not disclose their monthly HHI. An observation was made that of those maize meal consumers who did not disclose their HHI, 2.5% (n = 73) were students. The majority (n = 365; 15.5%) of the maize meal consumer households earned between R4 001 - R6 000, whilst the minority (n = 14; 0.6%) earned R500 and less per month. The same pattern appeared in the total population whereby the majority of households (n = 390; 13.9%) earned between R4 001 - R6 000 and the minority (n = 15; 0.5%) earned R500 and less per month (Table 4.2).

Approximately 65.6% (n = 1 546) of the maize meal consumers were formally employed, whilst nine percent (n = 212) were unemployed and the remaining (24.6%) were either self-employed (n = 202; 8.6%), students (n = 151; 6.4%), housewives (n = 123; 5.2%) or pensioners (n = 104; 4.4%). No information on employment was available for 0.8% (n = 18) of the maize meal consumers. Sixty seven percent (n = 305) of the non-consumers of maize meal were formally employed. Students accounted for 6.0% (n = 27), housewives 5.3% (n = 24) and pensioners 2.6% (n = 12) of the non-consumers. Information on employment was not available for 1.3% (n = 6) of non-consumers. Forty-five percent (n = 1 262) of the total population attained a grade 12 certificate, whilst 31% (n = 877) achieved a technikon or university qualification (Table 4.2).

The data on maize meal intake of the consumers, non-consumers and total population was also stratified by province. In the Eastern Cape 12.8% (n = 302) were maize meal consumers, and the highest number (n = 562; 23.9%) of maize meal consumers resided within Gauteng. KwaZulu-Natal represented 13.3% (n = 313) of the maize meal consumers and 20.3% (n = 92) of the non-consumers (Table 4.2). The percentage of maize meal consumers within each province was highest in the Free State (92.5%) followed by Mpumalanga (91.7%), Limpopo (90.8%), Gauteng (88.2%), Eastern Cape (85.8%), Northern Cape (83.3%), North West (81.8%), KwaZulu-Natal (77.3%) and the lowest in the Western Cape (64.9%).

4.4.2 Maize meal intakes of consumers

In Table 4.3, the mean amount (in gram) of maize meal consumed by gender, ethnic group, age category, province and HHI categories for the maize meal consumers (n = 2 356) are displayed. The mean amount of maize meal consumed by males (n = 663; 28.1%) was 616 g compared to 572 g by females (n = 1 693; 71.9%) and for all the consumers it was 584 g (SD = 542 g). The black African ethnic group (n = 1 698; 72.1%) consumed the highest mean amount (667 g) of maize meal, followed by South Africans of mixed ancestry (461 g), Indian South Africans (309 g) and then the Caucasian population group (266 g). The mean (Standard Deviation) portion of cooked maize meal was as follows in the respective age categories: 14 - 18 (592 g; SD = 417 g), 19 - 30 (601 g; SD = 560 g), 31 - 50 (572 g; SD = 550 g), 51 - 70 (567 g; SD = 432 g) and 71+ (557 g; SD = 387 g). Among those who consumed maize meal in the various age cateories, the 19 - 30 year old group (n = 1 084; 46.0%) consumed the highest mean amount of maize meal at 601 g (range 5 - 6 546 g) and the 71 years and older age group (n = 21; 0.9%) consumed the smallest amount (557 g; range 44 - 1 765 g) (Table 4.3). The different average portion sizes of maize meal consumed by the various age categories indicated that the 14 - 18 year age category consumed the second largest portion at 592 g which comprised 242 g, 219 g and 131 g of soft, stiff and crumbly maize meal porridge, respectively. The mean portion size of crumbly maize meal porridge consumed by this age category indicated to be the biggest (131 g) for the various age categories. Participants from the Mpumalanga province (n = 176; 7.5%) consumed the highest (731 g; range 23 - 6 546 g) mean amount of maize meal while participants from the North West province (n = 198; 8.4%) consumed the least (469 g; range 5 - 3 847 g).

In the different categories of the HHI, the individuals earning the least amount of money (R500 and less) consumed the highest mean amount (755 g; range 99 - 3 820 g) of maize meal. The consumers of maize meal earning over R10 000 (n = 157; 6.7%) consumed the least (401 g; range 5 - 2 763 g). For participants who did not disclose their household income, the mean amount of maize meal consumed was similar (589 g) to those participants (584 g) who earned between R6 001 - R8 000.

The average portion of cooked maize meal consumed per day by those who indicated their age (n = 2 344) was 585 g (SD = 543 g) comprised 257 g each for soft and stiff maize meal porridge and 71 g of crumbly maize meal porridge. This is equivalent to 45 g, 106 g and 45 g of raw maize meal for soft, stiff and crumbly porridge respectively and amounts to a total of 196 g raw maize meal.

Table 4.3: Amount of maize meal eaten by consumers stratified by gender, ethnic group, age category, province and household income category (n = 2 356)

	Maize meal consumers	
	n (%)	**Mean (SD) maize meal amount consumed (g); range**
Gender		
Male	663 (28.1)	616 (608); 6 - 6 546
Female	1 693 (71.9)	572 (514); 5 - 7 798
Ethnic group		
Black African	1 698 (72.1)	667 (583); 8 - 7 798
Mixed ancestry	336 (14.3)	461 (329); 9 - 2 445
Caucasian	255 (10.8)	266 (309); 5 - 2 900
Indian South Africans	67 (2.8)	309 (330); 5 - 1 406
Age category (years)		
14 - 18	38 (1.6)	592 (417); 68 - 1 831
19 - 30	1 084 (46.0)	601 (560); 5 - 6 546
31 - 50	1 012 (43.0)	572 (550); 5 - 7 798
51 - 70	189 (8.0)	567 (432); 11 - 4 399
71+	21 (0.9)	557 (387); 44 - 1 765
No information	12 (0.5)	380 (245); 19 - 783
Province		
Eastern Cape	302 (12.8)	534 (351); 6 - 2 763
Free State	175 (7.4)	552 (443); 25 - 3 038
Gauteng	562 (23.9)	572 (643); 5 - 7 798
KwaZulu-Natal	313 (13.3)	653 (417); 20 - 2 433
Northern Cape	120 (5.1)	588 (290); 5 - 1 388
North West	198 (8.4)	469 (420); 5 - 3 847
Western Cape	196 (8.3)	505 (352); 8 - 2 445
Limpopo	314 (13.3)	640 (469); 5 - 4 106
Mpumalanga	176 (7.5)	731 (1 031); 23 - 6 546
Household income* category		
R500 and less	14 (0.6)	755 (459); 99 - 3 820
R501 - R1 000	37 (1.6)	672 (391); 44 - 1 596
R1 001 - R2 000	144 (6.1)	671 (484); 44 - 3 820
R2 001 - R4 000	326 (13.8)	617 (407); 11 - 3 093
R4 001 - R6 000	365 (15.5)	659 (766); 8 - 7 798
R6 001 - R8 000	325 (13.8)	584 (652); 11 - 6 546
R8 001 - R10 000	256 (10.9)	462 (425); 12 - 3 818
Over R10 000	157 (6.7)	401 (376); 5 - 2 763
Not disclosed	732 (31.1)	589 (472); 5 - 4 399
Total mean (SD) amount of maize meal (g)		**584 (542)**

*Household income per month

4.4.3 Macronutrient intakes of consumers

The energy and macronutrient intakes from maize meal in the consumers group are provided in Table 4.4.

Table 4.4: Macronutrient intake from maize meal by consumers per age category for energy, protein, fat, available carbohydrate and dietary fibre (n = 2 344*)

Age category (n)	Energy	Protein	Fat	Available Carbohydrate**	Dietary fibre
	Mean (SD) kJ Median (IQR1***; IQR3#) kJ % of EER## Mean (Median)	Mean (SD) g Median (IQR1; IQR3) g % of RDA### Mean (Median)	Mean (SD) g Median (IQR1; IQR3) g -	Mean (SD) g Median (IQR1; IQR3) g % of RDA### Mean (Median)	Mean (SD) g Median (IQR1; IQR3) g % of AI§ Mean (Median)
All age categories (2 344)	2 232 (2 069) 1 837 (1 057; 2 855) 21 (17)	12.6 (11.7) 10.2 (5.9; 16.1) 26 (21)	3.0 (2.7) 2.6 (1.4; 3.9) -	120.3 (111.6) 98.1 (57.0; 152.8) 93 (75)	9.4 (8.6) 7.8 (4.5; 12.1) 34 (28)
14 - 18 (38)	2 486 (2 215) 1 835 (1 291; 2 869) 24 (18)	13.9 (12.7) 10.4 (7.3; 15.7) 30 (23)	3.1 (2.3) 2.5 (1.5; 4.2) -	134.7 (120.2) 99.1 (70.4; 154.9) 104 (76)	10.3 (8.4) 7.2 (5.6; 12.9) 37 (27)
19 - 30 (1 084)	2 280 (2 118) 1 873 (1 091; 2 908) 21 (17)	12.8 (12.0) 10.6 (6.2; 16.6) 26 (22)	3.1 (2.8) 2.6 (1.5; 3.9) -	122.8 (114.3) 100.0 (58.5; 155.3) 94 (77)	9.7 (8.9) 8.1 (4.6; 12.3) 34 (29)
31 - 50 (1 012)	2 195 (2 093) 1 760 (976; 2 776) 20 (16)	12.4 (11.9) 10.0 (5.4; 15.7) 25 (21)	2.9 (2.8) 2.5 (1.4; 3.9) -	118.3 (112.8) 95.0 (52.6; 149.6) 91 (73)	9.3 (8.7) 7.6 (4.2; 11.9) 33 (27)
51 - 70 (189)	2 114 (1 644) 1 810 (1 086; 2 863) 20 (17)	11.9 (9.4) 10.0 (6.2; 16.7) 25 (20)	2.9 (2.2) 2.6 (1.5; 4.0) -	113.6 (88.1) 95.5 (57.7; 153.8) 87 (73)	9.0 (6.8) 7.9 (4.8; 12.1) 40 (34)
71+ (21)	2 163 (1 524) 1 756 (1 263; 2 410) 20 (17)	12.3 (8.6) 10.1 (7.4; 13.9) 25 (20)	2.9 (2.0) 2.5 (1.7; 3.4) -	116.3 (82.3) 93.3 (67.2; 129.4) 89 (72)	9.1 (6.3) 7.7 (5.1; 10.4) 39 (30)

*Information on age was not available for 12 of the maize meal consumers and intake expressed as a percentage of the EER, RDA or AI for only those maize meal consumers who indicated their age
** Available carbohydrate (defined as the sum of the free sugars, dextrins, starch and glycogen)[25] expressed as a percentage of the RDA and defined as total carbohydrate (starches and sugars) in the DRI report[24]
***Interquartile range 1
Interquartile range 3
%EER-Percentage Estimated Energy Requirement reported for mean (median) intake
%RDA-Percentage Recommended Dietary Allowance reported for mean (median) intake
§ %AI-Percentage Adequate Intake reported for mean (median) intake

Intakes were expressed as a percentage of the EER, RDA or AI for the respective age categories for only those maize meal consumers who indicated their age (n = 2 344). Median energy intake from maize meal of the group was 1 837 kJ, and provided 17% of the EER. Median intake of available carbohydrates[24,25] was 75% of the RDA, while protein and dietary fibre intakes were 21% and 28% respectively. The median energy intake in the various age categories of the maize meal consumers ranged from 1 756 kJ (71+ age category) to 1 873 kJ (19 - 30 year age category) and provided 17% of the EER for both age groups. The contribution (% median RDA) of maize meal to carbohydrate was highest (77%) in the 19 - 30 year age category, the contribution to dietary fibre was highest (34%) in the 51 - 70 year age category and to protein was highest (23%) in 14 - 18 year age category. The contribution (% median RDA) of maize meal to carbohydrate was lowest (72%) in the 71+ year age category, to dietary fibre it was lowest (27%; 27%) in the 14 - 18 and 31 - 50 year age categories and to protein was lowest (20%; 20%) in the 51 - 70 and 71+ year age categories.

The energy and macronutrient intake from maize meal of the male and female maize meal consumers are provided in Table 4.5. The intakes are expressed as a percentage of the EER, RDA or AI for the respective age categories for only those participants who indicated their age (n = 2 344). The differences between the mean and median values indicated that the dietary intake data were skew and therefore the medians are also reported. The median energy intakes of the males and females was 1 984 kJ and 1 769 kJ respectively, representing 15% and 18% of the EER. Protein intakes for males and females were 20% and 22% respectively. The median intake of available carbohydrates for males and females was 82% and 73% of the RDA, while median dietary fibre intake was 23% and 31% of the AI, respectively.

Table 4.5: Macronutrient intake from maize meal, male (n = 661)* and female (n = 1 683)* consumers

Macronutrient	Mean (SD)		Median (IQR1**; IQR3***)		% of DRI# Mean (Median)	
	Males	Females	Males	Females	Males	Females
Energy (kJ)	2 390 (2 260)	2 171 (1 987)	1 984 (1 175; 2867)	1 769 (1 016; 2 807)	19 (15)	22 (18)
Protein (g)	13.5 (12.8)	12.2 (11.2)	11.2 (6.7; 16.5)	9.9 (5.6; 15.8)	24 (20)	27 (22)
Fat (g)	3.2 (3.1)	2.9 (2.6)	2.7 (1.6; 4.0)	2.5 (1.4; 3.9)	-	-
Available Carbohydrate##(g)	128.6 (121.6)	117.0 (107.2)	106.3 (63.6;154.0)	95.0 (54.4;151.8)	99 (82)	90 (73)
Dietary fibre (g)	10.1 (9.5)	9.2 (8.2)	8.5 (5.2; 12.1)	7.6 (4.3; 12.1)	27 (23)	37 (31)

*Information on age was not available for 12 of the participating maize meal consumers
**Interquartile range 1, ***Interquartile range 3
%DRI-Percentage Dietary Reference Intakes (DRI) reported for mean (median) intake according to respective age and gender categories. For energy the EER was used, for protein and available carbohydrate the RDA and the AI for fibre[22,23,24]
Available carbohydrate (defined as the sum of the free sugars, dextrins, starch and glycogen)[25] expressed as a percentage of the RDA and defined as total carbohydrate (starches and sugars) in the DRI report[24]

4.4.4 Micronutrient intakes of consumers

The micronutrient intake from maize meal in the consumers group is shown in Table 4.6. The intake was expressed as a percentage of the EAR for each of the maize meal consumers who indicated their age (n = 2 344). The median micronutrient intake of the group (n = 2 344) from maize meal was less than 67% of the EAR for all micronutrients, except for folate and iron with median intakes at 67% and 72% of the EAR respectively.

Maize meal made the biggest contribution to vitamin A (32%), thiamine (60%), riboflavin (22%), niacin (48%) and vitamin B_6 (51%) of the EAR in the 14 - 18 year age category, whereas it made the biggest contribution to folate (69%) in the 19 - 30 year age category, the biggest contribution to iron (99%) in both the 51 - 70 and 71+ year age categories and the biggest contribution to zinc (34%) in the 14 - 18, 19 - 30 and 51 - 70 year age categories. All age categories, with the exception of the 71+ age group, included individuals where maize meal contributed 100% of the EAR for micronutrients (vitamin A, riboflavin, vitamin B_6, thiamine, niacin, folate, iron and zinc). In the 71+ age category, there were no individuals who obtained 100% of the EAR for vitamin A and riboflavin from maize meal. Except for the 14 - 18 year old category, the median intake of iron in all age categories reached 67% of the EAR. Only in the 19 - 30 and 51 - 70 year age categories 67% of the EAR for folate was reached.

Table 4.6: Micronutrient intake from maize meal by all consumers (n = 2 344*) and per age category

Age category (n)	Vitamin A	Thiamine	Riboflavin	Niacin	Vitamin B_6	Folate	Iron	Zinc
	Mean (SD) µg RE** Median (IQR1***; IQR3#) µg RE % of EAR## Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) µg Median (IQR1; IQR3) µg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)
All age categories (2 344)	172 (168) 135 (75; 217) 32 (25)	0.65 (0.60) 0.53 (0.31; 0.83) 70 (57)	0.24 (0.22) 0.19 (0.11; 0.30) 25 (20)	6.4 (6.0) 5.2 (3.0; 8.1) 57 (46)	0.621 (0.578) 0.500 (0.291; 0.784) 56 (45)	252 (229) 214 (121; 327) 79 (67)	6.5 (6.0) 5.3 (3.1; 8.2) 91 (72)	3.08 (2.86) 2.52 (1.46; 3.95) 42 (34)
14 - 18 (38)	204 (205) 158 (91; 222) 40 (32)	0.73 (0.65) 0.54 (0.38; 0.84) 80 (60)	0.26 (0.24) 0.19 (0.14; 0.30) 28 (22)	7.3 (6.7) 5.3 (3.6; 8.3) 66 (48)	0.704 (0.632) 0.509 (0.360; 0.805) 69 (51)	268 (207) 215 (136; 371) 81 (65)	7.2 (6.3) 5.2 (3.8; 8.4) 91 (66)	3.44 (3.09) 2.56 (1.75; 3.92) 45 (34)
19 - 30 (1 084)	175 (172) 138 (82; 219) 33 (26)	0.67 (0.62) 0.54 (0.32; 0.84) 72 (59)	0.24 (0.22) 0.20 (0.12; 0.31) 25 (21)	6.5 (6.2) 5.3 (3.1; 8.3) 58 (46)	0.635 (0.593) 0.516 (0.299; 0.800) 58 (47)	258 (236) 220 (126; 329) 81 (69)	6.6 (6.1) 5.4 (3.1; 8.4) 91 (72)	3.15 (2.93) 2.58 (1.50; 4.02) 42 (34)

*Information on age was not available for 12 of the maize meal consumers
**Vitamin A reported in µg RE but compared to RAE of the DRI[20,22]. Vitamin A fortificant in the form of retinol and 1 µg retinol = 1 µg RAE
***Interquartile range 1
Interquartile range 3
%EAR-Percentage Estimated Average Requirement (EAR) reported for mean (median) intake according to respective age categories[22,23]

Table 4.6 (contd): Micronutrient intake from maize meal by all consumers (n = 2 344*) and per age category

Age category (n)	Vitamin A	Thiamine	Riboflavin	Niacin	Vitamin B_6	Folate	Iron	Zinc
	Mean (SD) µg RE** Median (IQR1***; IQR3#) µg RE % of EAR## Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) µg Median (IQR1; IQR3) µg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)	Mean (SD) mg Median (IQR1; IQR3) mg % of EAR Mean (Median)
31 - 50 (1 012)	170 (169) 131 (69; 214) 32 (25)	0.64 (0.61) 0.52 (0.29; 0.81) 69 (56)	0.23 (0.22) 0.19 (0.10; 0.29) 25 (20)	6.3 (6.1) 5.0 (2.8; 8.0) 56 (44)	0.611 (0.585) 0.486 (0.272; 0.773) 56 (44)	247 (232) 204 (114; 322) 77 (64)	6.3 (6.0) 5.1 (2.8; 8.0) 86 (68)	3.03 (2.90) 2.43 (1.34; 3.83) 41 (32)
51 - 70 (189)	159 (128) 128 (76; 221) 30 (24)	0.62 (0.48) 0.52 (0.31; 0.83) 67 (56)	0.22 (0.18) 0.19 (0.12; 0.31) 24 (20)	6.0 (4.6) 5.0 (3.1; 8.0) 53 (44)	0.584 (0.452) 0.489 (0.295; 0.793) 44 (37)	241 (182) 218 (128; 323) 75 (68)	6.1 (4.7) 5.2 (3.1; 8.3) 117 (99)	2.92 (2.27) 2.49 (1.50; 3.96) 40 (34)
71 - 88 (21)	166 (124) 125 (89; 179) 31 (25)	0.63 (0.45) 0.51 (0.36; 0.70) 68 (56)	0.23 (0.16) 0.19 (0.14; 0.26) 24 (20)	6.2 (4.4) 4.7 (3.5; 6.8) 55 (43)	0.599 (0.428) 0.471 (0.342; 0.665) 45 (36)	241 (167) 209 (142; 280) 75 (65)	6.2 (4.4) 5.1 (3.6; 7.0) 119 (99)	2.99 (2.11) 2.42 (1.75; 3.32) 40 (32)

*Information on age was not available for 12 of the maize meal consumers
**Vitamin A reported in µg RE but compared to RAE of the DRI[20,22]. Vitamin A fortificant in the form of retinol and 1 µg retinol = 1 µg RAE
*** Interquartile range 1
# Interquartile range 3
%EAR-Percentage Estimated Average Requirement (EAR) reported for mean (median) intake according to respective age categories[22,23]

The micronutrient intakes from maize meal of the male and female maize meal consumer groups are provided in Table 4.7. The intake was expressed as a percentage of the EAR for the respective age categories for only those participants who indicated their age (n = 2 344). The median intake was at least 67% of the EAR for folate (71%) and iron (96%) for the males (n = 661) whereas all other micronutrients were below 67%. For the females (n = 1 683) none of the median micronutrient intakes reached 67% of the EAR.

The percentage and number of males for whom maize meal contributed 100% and more of the EAR was as follows: riboflavin 0.6% (n = 10), vitamin A 1.0% (n = 16), zinc 1.4% (n = 23), niacin 4.0% (n = 67), vitamin B_6 4.9% (n = 82), thiamine 6.8% (n = 115), folate 10.8% (n = 181) and iron 18.2% (n = 306). The percentage and number of females for whom maize meal contributed 100% and more of the EAR was as follows: riboflavin 1.2% (n = 20), vitamin A 3.6% (n = 60), zinc 6.3% (n = 106), vitamin B_6 10.6% (n = 179), niacin 12.4% (n = 208), thiamine 21.9% (n = 368), folate 26.1% (n = 440) and iron 27.7% (n = 467). For the group as a whole, fortified maize meal contributed to 100% of the EAR for iron, thiamin and folate for a third (n = 773; 33%), a fifth (n = 483; 20.6%) and 26.5% (n = 621) of the maize meal consumers (n = 2 344) respectively.

Table 4.7: Micronutrient intake from maize meal, male (n = 661)* and female (n = 1 683)* consumers

Micronutrient	Mean (SD)		Median (IQR1**; IQR3***)		% of EAR# Mean (Median)	
	Males	Females	Males	Females	Males	Females
Vitamin A (µg RE##)	184 (179)	167 (163)	144 (87; 223)	130 (73; 215)	29 (23)	33 (26)
Thiamine (mg)	0.70 (0.66)	0.63 (0.58)	0.58 (0.34; 0.83)	0.52 (0.30; 0.82)	70 (58)	71 (57)
Riboflavin (mg)	0.25 (0.24)	0.23 (0.21)	0.21 (0.13; 0.31)	0.19 (0.11; 0.30)	23 (19)	26 (21)
Niacin (mg)	6.8 (6.5)	6.2 (5.8)	5.5 (3.3; 8.2)	5.0 (2.9; 8.0)	57 (46)	57 (45)
Vitamin B_6 (mg)	0.663 (0.628)	0.605 (0.557)	0.542 (0.318; 0.797)	0.490 (0.280; 0.779)	59 (49)	54 (44)
Folate (µg)	267 (254)	246 (219)	226 (138; 327)	207 (117; 327)	83 (71)	77 (65)
Iron (mg)	6.9 (6.5)	6.3 (5.7)	5.7 (3.4; 8.3)	5.1 (2.9; 8.1)	115 (96)	82 (65)
Zinc (mg)	3.30 (3.12)	3.00 (2.75)	2.73 (1.64; 3.96)	2.43 (1.39; 3.91)	35 (29)	44 (36)

* Information on age was not available for 12 of the maize meal consumers
** Interquartile range 1
*** Interquartile range 3
\# %EAR-Percentage Estimated Average Requirement (EAR) reported for mean (median) intake according to respective age categories[22,23]
\## Vitamin A reported in µg RE but compared to RAE of the DRI.[20,22] Vitamin A fortificant in the form of retinol and 1 µg retinol = 1 µg RAE

For vitamin A, maize meal did not contribute enough to meet the requirements, as recommended by the food legislation guidelines, for both males (20%) and females (24%). Maize meal contributed up to 58% of the RDA for thiamine for males and females. As for riboflavin, maize meal contributed 20% for males and 21% for females. For niacin, maize meal contributed to 43% for males and 45% females of the RDA. The mean percentage contribution of maize meal to the RDA for folate, zinc and vitamin B_6 in both gender groups was more than the RDA set out by legislation. Maize meal contributed up to 86% of the RDA for iron for males and 39% for females.

The mean macro-and-micronutrient intakes of both male and female maize meal consumers substituting unfortified maize meal with fortified maize meal are given in Tables 4.8 and 4.9 respectively. The micronutrient intakes of males (Table 4.8) and females (Table 4.9) were significantly ($p<0.0001$) higher for all micronutrients, that form part of the national food fortification programme, with fortified maize meal than unfortified maize meal. Whilst riboflavin intake for males and females illustrated a significant ($p<0.0001$) difference, the intake decreased instead of increased. The same pattern was observed for protein, available carbohydrate, total dietary fibre and energy.

The EER for males (aged 19 - 70+) is 12 881 kJ.[24] The AMDR for fat, total carbohydrate (available carbohydrate plus dietary fibre)[25] and protein is estimated to be 20-35%, 45-65% and 10-35% of energy respectively for adults.[24] The percentage contribution of fortified maize meal to the total carbohydrate (available carbohydrate plus dietary fibre)[25], protein and fat intake of a 12 881 kJ diet (males) was 18.3%, 1.8% and 0.9% of total energy respectively. The EER for females (aged 19 - 70+) is 10 093 kJ.[24] The percentage contribution of fortified maize meal to the total carbohydrate (available carbohydrate plus dietary fibre)[25], protein and fat intake of a 10 093 kJ diet was 21.2%, 2.1% and 1.1% of total energy respectively.

Table 4.8: Comparison of macro- and -micronutrient intakes of males, substituting unfortified maize meal with fortified maize meal (n = 663)*

Males (n = 663)									
	Unfortified				Fortified				Diff**
Nutrient	Mean	SD	Range	Median	Mean	SD	Range	Median	p-value
Energy (kJ)	2 440	2 309	17 - 21 914	2 028	2 385	2 259	17 - 21 412	1 982	<0.0001
Total protein (g)	13.9	13.2	0.1 - 124.1	11.4	13.5	12.8	0.1 - 120.7	11.1	<0.0001
Total fat (g)	3.0	2.9	0.0 - 29.3	2.6	3.2	3.1	0.0 - 32.6	2.7	<0.0001
Available carbohydrate (g)	130.2	123.3	0.9 - 1 161.5	107.6	128.3	121.5	0.9 - 1 145.5	106.2	<0.0001
Total dietary fibre (g)	12.6	11.9	0.1 - 114.4	10.5	10.0	9.5	0.1 - 94.9	8.5	<0.0001
Vitamin A (µg RE)	-	-	-	-	184	179	1 - 1 495	143	<0.0001
Thiamine (mg)	0.22	0.21	0.0 - 1.96	0.18	0.70	0.66	0.0 - 6.22	0.58	<0.0001
Riboflavin (mg)	0.35	0.36	0.0 - 3.87	0.30	0.25	0.24	0.0 - 2.28	0.21	<0.0001
Niacin (mg)	2.0	1.9	0.0 - 19.5	1.7	6.8	6.5	0.0 - 59.1	5.5	<0.0001
Vitamin B_6 (mg)	0.169	0.160	0.001 - 1.595	0.142	0.662	0.628	0.005 - 5.837	0.542	<0.0001
Folate (µg)	13	21	0 - 251	5	267	254	3 - 2 619	226	<0.0001
Iron (mg)	2.1	2.0	0.0 - 19.6	1.8	6.9	6.5	0.0 - 62.1	5.7	<0.0001
Zinc (mg)	1.12	1.06	0.01 - 10.73	0.95	3.30	3.12	0.02 - 29.42	2.73	<0.0001

*Values based on calculating the mean nutrient intake from unfortified and fortified maize meal porridge. Nutrient intake based on mean portion of maize meal consumed by male consumers (n = 663) of 616 g maize meal porridge comprising 253 g soft, 290 g stiff and 73 g crumbly maize meal porridge

**Wilcoxon signed-rank test to test for differences between unfortified and fortified values

Table 4.9: Comparison of macro- and -micronutrient intakes of females, substituting unfortified maize meal with fortified maize meal (n = 1 693)*

Females (n = 1 693)									
	Unfortified				Fortified				Diff**
Nutrient	Mean	SD	Range	Median	Mean	SD	Range	Median	p-value
Energy (kJ)	2 219	2 028	17 - 25 860	1 811	2 167	1 983	17 - 25 212	1 766	<0.0001
Total protein (g)	12.6	11.6	0.1 - 146.9	10.2	12.2	11.2	0.1 - 140.9	9.9	<0.0001
Total fat (g)	2.7	2.4	0.0 - 33.4	2.3	2.9	2.6	0.0 - 37.9	2.5	<0.0001
Available carbohydrate (g)	118.4	108.5	0.9 - 1 396.8	96.2	116.8	107.0	0.9 - 1 380.0	95.0	<0.0001
Total dietary fibre (g)	11.4	10.4	0.1 - 129.7	9.4	9.2	8.2	0.1 - 109.2	7.6	<0.0001
Vitamin A (µg RE)	-	-	-	-	167	162	1 - 2 341	130	<0.0001
Thiamine (mg)	0.20	0.18	0.00 - 2.30	0.16	0.63	0.58	0.0 - 7.48	0.52	<0.0001
Riboflavin (mg)	0.31	0.29	0.00 - 0.46	0.27	0.23	0.21	0.0 - 2.64	0.19	<0.0001
Niacin (mg)	1.8	1.7	0.0 - 22.3	1.5	6.2	5.8	0.0 - 78.5	5.0	<0.0001
Vitamin B_6 (mg)	0.153	0.138	0.001 - 1.805	0.126	0.604	0.556	0.005 - 7.351	0.490	<0.0001
Folate (µg)	12	20	0 - 340	6	245	218	2 - 3 052	207	<0.0001
Iron (mg)	1.9	1.7	0.0 - 22.3	1.6	6.3	5.7	0.0 - 72.4	5.1	<0.0001
Zinc (mg)	1.01	0.91	0.01 - 12.14	0.84	2.99	2.75	0.02 - 35.15	2.43	<0.0001

*Values based on calculating the mean nutrient intake from unfortified and fortified maize meal. Nutrient intake based on mean portion of maize meal consumed by female consumers (n = 1 693) of 572 g maize meal porridge comprising 258 g soft, 244 g stiff and 70 g crumbly maize meal porridge
**Wilcoxon signed-rank test to test for differences between unfortified and fortified values

4.4.5 Households living above and below the poverty line

Data were analysed to determine the number and percentage of participating households in South Africa living above and below the poverty line (R2 000 per month). In total, 195 (8.3%) households lived below the poverty line (as illustrated in Table 4.10). Data for the different ethnic groups showed that 183 (7.8%) Black African, nine (0.4%) mixed ancestry, two (0.08%) Caucasian and one (0.04%) Indian South African households of the maize meal consumers group lived below the poverty line (R2 000 per month). The number of households of the maize meal consumers group living below the poverty line in the various provinces was as follows: Gauteng 55 (2.3%), KwaZulu-Natal 45 (1.9%), Limpopo 29 (1.2%), North West 22 (0.9%), Eastern Cape 16 (0.7%), Western Cape 12 (0.5%), Free State 9 (0.4%), Mpumalanga 7 (0.3%) with the Northen Cape not having any households below the poverty line. The number of households above the poverty line from the various provinces was as follows: Gauteng 507 (21.5%), Eastern Cape 286 (12.1%), Limpopo 285 (12.1%), KwaZulu-Natal 268 (11.4%), Western Cape 184 (7.8%), North West 176 (7.5%), Mpumalanga 169 (7.2%), Free State 166 (7.0%) and Northern Cape 120 (5.1%).

Table 4.10: Number and percentage of maize meal consumers living above and below the poverty line (R2 000 per month), (n = 2 356)

	Above the poverty line										Below the poverty line									
Ethnic group	**EC**	**FS**	**GP**	**KZN**	**NC**	**NW**	**WC**	**LP**	**MP**	**Total above***	**EC**	**FS**	**GP**	**KZN**	**NC**	**NW**	**WC**	**LP**	**MP**	**Total below#**
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
African	182 (8.4)	104 (4.8)	354 (16.3)	219 (10.1)	46 (2.1)	119 (5.5)	79 (3.6)	261 (12.0)	151 (6.9)	1515 (70.1)	16 (8.2)	7 (3.5)	55 (28.2)	42 (21.5)	-	22 (11.2)	5 (2.5)	29 (14.8)	7 (3.5)	183 (93.8)
Mixed ancestry	62 (2.8)	41 (1.8)	40 (1.8)	11 (0.5)	49 (2.2)	35 (1.6)	89 (4.1)	-	-	327 (15.1)	-	2 (1.0)	-	-	-	-	7 (3.5)	-	-	9 (4.5)
Cauca-sian	42 (1.9)	21 (0.9)	82 (3.7)	17 (0.7)	25 (1.1)	16 (0.7)	8 (0.3)	24 (1.1)	18 (0.8)	253 (11.7)	-	-	-	2 (1.0)	-	-	-	-	-	2 (1.0)
Indian South Africans	-	-	31 (1.4)	21 (0.9)	-	6 (0.2)	8 (0.3)	-	-	66 (3.0)	-	-	-	1 (0.5)	-	-	-	-	-	1 (0.5)
Total	**286 (12.1)**	**166 (7.0)**	**507 (21.5)**	**268 (11.4)**	**120 (5.1)**	**176 (7.5)**	**184 (7.8)**	**285 (12.1)**	**169 (7.2)**	**2161 (91.7)**	**16 (0.7)**	**9 (0.4)**	**55 (2.3)**	**45 (1.9)**	**0**	**22 (0.9)**	**12 (0.5)**	**29 (1.2)**	**7 (0.3)**	**195 (8.3)**

EC=Eastern Cape, FS=Free State, GP=Gauteng Province, KZN=KwaZulu-Natal, NC=Northern Cape, NW=North West Province, WC=Western Cape, LP=Limpopo Province, MP=Mpumalanga Province

*= Total number and percentage of people from the maize meal consumers group living above the poverty line

#= Total number and percentage of people from the maize meal consumers group living below the poverty line

4.4.6 Micronutrient intakes of unemployed and employed consumers

The micronutrient intakes of the maize meal consumers were categorised according to employment status (Table 4.11). The mean portion sizes of maize meal consumed by the unemployed and employed maize meal consumers were 696 g (SD = 504 g) and 564 g (SD = 519 g) respectively. Maize meal intake of the unemployed maize meal consumers were significantly (p <0.001) higher than those of the employed maize meal consumers. The six vitamins and two minerals which form part of the national fortification programme were therefore significantly (p <0.001) higher in the unemployed consumers (Table 4.11).

Of those who were unemployed in the maize meal consumers group, the highest number (n = 42; 19.8%) came from the Eastern Cape, followed by the Gauteng (n = 38; 17.9%), KwaZulu-Natal (n = 37; 17.5%), Limpopo (n = 32; 15.1%), Northern Cape (n = 16; 7.6%), Western Cape (n = 15; 7.1%), Free State (n = 13; 6.1%) and Mpumalaga (n = 12; 5.7%) while the lowest number of unemployed participants came from the North West (n = 7; 3.3%). For those maize meal consumers who were employed the distribution followed a different pattern. Employment was highest in the Gauteng (n = 387; 25.0%), followed by Limpopo (n = 211; 13.7%), KwaZulu-Natal (n = 183; 11.8%), Eastern Cape (n = 168; 10.9%), Western Cape (n = 156; 10.1%), North West (n = 129; 8.3%), Mpumalanga (n = 121; 7.8%), Free State (n = 113; 7.3%) and Northern Cape (n = 78; 5.1%).

Approximately 65.6% (n = 1 546) of the maize meal consumers were formally employed, whilst nine percent (n = 212) were unemployed. The remaining (24.6%) were either self-employed (n = 202; 8.6%), students (n = 151; 6.4%), housewives (n = 123; 5.2%) or pensioners (n = 104; 4.4%). Comparison of results for formally employed versus unemployed participants, using the Pearson's chi-square test, for male and female maize meal consumers, showed that significantly (p <0.001) more females than males were unemployed.

Table 4.11: Contribution of fortified maize meal to the nutrient intake of unemployed (n = 212) compared to the employed (n = 1 546) maize meal consumers

Micronutrient	Unemployed (n = 212)					Employed (n = 1 546)					p-value*
	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max	
Vitamin A (µg RE)	212	199	169	3	2 340	166	160	130	0.9	1 559	<0.001
Thiamine (mg)	0.79	0.66	0.65	0.01	7.47	0.63	0.57	0.51	0.01	6.21	<0.001
Riboflavin (mg)	0.28	0.23	0.23	0.00	2.63	0.23	0.21	0.19	0.00	2.28	<0.001
Niacin (mg)	7.85	6.77	6.60	0.09	78.48	6.20	5.74	4.97	0.05	59.13	<0.001
Vitamin B_6 (mg)	0.758	0.643	0.637	0.010	7.351	0.602	0.554	0.490	0.005	5.837	<0.001
Folate (µg)	302	230	266	4	2 419	243	219	206	2	2 619	<0.001
Iron (mg)	7.8	6.4	6.5	0.1	72.3	6.2	5.7	5.1	0.1	62.1	<0.001
Zinc (mg)	3.73	3.13	3.10	0.05	35.14	2.98	2.73	2.47	0.02	29.42	<0.001

*Wilcoxon rank sum test to test for differences between mean intakes

4.4.7 Micronutrient intakes of Household income groups

Data were analysed to test for differences in micronutrient intake in the HHI groups for consumers of maize meal above the poverty line compared to HHI groups below the poverty line. For HHI categories earning above R6 000 per month the zinc intakes were significantly lower than HHI categories earning below R2 000 per month. The same pattern was followed for vitamin A, vitamin B_6, thiamine, niacin, riboflavin, iron and folate (Table 4.12).

Table 4.12: Mean micronutrient intakes from fortified maize meal for household income categories below the poverty line compared to household income categories above the poverty line (R2 000 per month)

Household income category	n	Maize meal (g)	Vitamin A (µg RE)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin B_6 (mg)	Folate (µg)	Iron (mg)	Zinc (mg)
Below R2 000	195	677	212	0.78	0.28	7.8	0.751	297	7.7	3.70
R2 001 - R4 000	326	617	201	0.74	0.27	7.3	0.706	275	7.2	3.50
*p-value**			0.458	0.408	0.478	0.354	0.378	0.278	0.416	0.439
R4 001 - R6 000	365	659	193	0.73	0.27	7.2	0.697	283	7.2	3.46
p-value			0.181	0.329	0.391	0.240	0.283	0.485	0.357	0.347
R6 001 - R8 000	325	584	168	0.64	0.23	6.3	0.610	250	6.3	3.02
p-value			0.003	0.008	0.010	0.005	0.006	0.020	0.009	0.009
R8 001 - R1 000	256	462	133	0.51	0.18	5.0	0.484	198	5.0	2.40
p-value			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Above R10 000	157	401	111	0.43	0.15	4.2	0.407	169	4.2	2.01
p-value			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Not disclosed	732	589	166	0.64	0.23	6.2	0.607	250	6.3	3.01
p-value			0.000	0.002	0.004	0.001	0.002	0.010	0.003	0.003

*p-value comparing household income categories to the poverty line below R2 000 using a generalised linear model

4.5. Discussion

This study aimed to determine the macronutrient and micronutrient intakes (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc) as derived from the maize meal consumption of a national sample of South Africans. The food composition database in SAFOODS was used for the macro- and- micronutrient analyses of the maize meal intake data.[20] Additionally, the energy, macro-and- micronutrient intakes from fortified maize meal were compared to the DRIs[22,23,24] for the different age and gender groups. The discussion is based on the results obtained from the secondary analyses of data from the original study entitled "Mycotoxins in South Africa: The effect of milling on mycotoxin levels and human exposure assessment".[12]

Maize meal is a good source of carbohydrates.[21] The RDA for available carbohydrate is set at 130 g for adults and children (excluding infants, pregnant and lactating women)[24] and the results of the present study showed that maize meal intake alone contributed to 75% of the RDA for available carbohydrate intake of maize meal consumers. Maize meal also contributed more than a quarter (28%) of the AI for dietary fibre and approximately a fifth (21%) of the RDA for protein, illustrating the importance of maize meal as a source of these nutrients. In a study done by Langenhoven, Wolmarans, Jooste, Dhansay and Benadé in 1995, on a representative sample of 2 000 South African adults, results showed that 27.3% of participants indicated maize as their staple food. The Caucasian (65%) and Indian South African (56%) population groups followed a mixed diet (no staple food), but maize was indicated as the staple food for 49% of the black African population and 8% of South Africans of mixed ancestry.[30] In population groups where maize meal is indicated as the staple food, the food fortification programme can make an important contribution to the intake of micronutrients especially those which form part of the fortification premix.[3]

Adequate intake of vitamins and minerals is important to prevent the development of micronutrient deficiency related diseases.[3] Folate, one of the B-vitamins, functions in the body as an essential nutrient for homocysteine metabolism and DNA synthesis.[31] Additionally, it plays a vital role in reducing a female's risk of giving birth to an infant with neural tube defects (NTD).[32] Iron is important for the synthesis of haemoglobin and myoglobin and deficiencies of iron may manifest as anaemia, while thiamine is important to prevent the deficiency disorder beri-beri. Previous studies among various ethnic groups in South Africa showed that population groups had low vitamin and mineral intakes, e.g. vitamins A, B_6, C, riboflavin, thiamine, niacin, folic acid, calcium, iron and zinc.[33,34,35,36,37] With the exception of the male group in the Ciskeian study[33], all the studies reported micronutrient intakes below 75% of the WHO recommendations. The 1999 NFCS showed that in children the intakes of calcium, iron, zinc, selenium, vitamins A, B_6, C, D and E, riboflavin, niacin and folic acid were inadequate and below two-thirds of the RDA.[5] Maize meal is known to be a commonly consumed staple food. It was therefore decided to use it as a vehicle for food fortification with vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc added to address micronutrient deficiencies in the country.[11] A South African study measuring the change in the prevalence of NTD before (January 2003-June 2004) and after (October 2004-June 2005) food fortification, showed a significant decline from 1.41 to 0.98 per 1 000 births.[38] In this study maize meal contributed to 100% and more of the EAR for iron, thiamine and folate for a third (n = 773; 32.9%), a fifth (n = 483; 20.6%) and 26.5% (n = 621) of the consumers respectively. The fortification of maize meal with these key nutrients therefore makes an important contribution to the micronutrient intakes of individuals.

Maize meal made the biggest contribution to the vitamin A, thiamine, riboflavin, niacin and vitamin B_6 intakes of the 14 - 18 year age category, whereas the biggest contribution to folate intake was in the 19 - 30 year age category. For iron the biggest contribution was in the 51 - 70 and 71+ year age categories, and for zinc in the 14 - 18, 19 - 30 and 51 - 70 year age categories. The average portion size (592 g) of maize meal consumed by the 14 - 18 year age category comprised 242 g, 219 g and 131 g of soft, stiff and crumbly maize meal porridge, respectively. Compared to soft (86.7 g per 100 g) and stiff (70.7 g per 100 g) maize meal porridge, crumbly maize meal porridge has the lowest moisture content (49.7 g per 100 g) and as a result, provides the most concentrated source of nutrients.[20,21,25] The contribution of the mean portion of maize meal porridge to the micronutrient intakes depended on the ratio of soft, stiff and crumbly porridge consumed by the participants. This was taken into account when the data were analysed. Since the 14 - 18 year age group consumed the biggest portion of crumbly maize meal compared to the other age categories, it could possibly explain why maize meal contributed the highest amount of vitamin A, thiamine, riboflavin, niacin and vitamin B_6 in this age category, even though the total mean amount of maize meal (i.e. soft, stiff and crumbly combined) consumed was not the largest portion for this age group.

In this study the average portion of cooked maize meal per day consumed by the group who indicated their age (n = 2 344) was 585 g (SD = 543 g) made up of 257 g soft and the same amount of stiff maize meal porridge plus 71 g of crumbly maize meal porridge, which is equivalent to one cup of soft and one cup of stiff maize meal porridge and approximately half a cup of crumbly maize meal porridge.[39] In 2006 a study done by Oldewage-Theron, Dicks and Napier, carried out in an urbanised informal settlement, reported that the average portion of maize meal porridge consumed by the female caregivers (n = 357) was approximately 532 g per day comprising 345 g stiff, 124 g soft and 63 g crumbly maize meal porridge.[40] In our study the average portion of cooked maize meal consumed by the females (n = 1 693) was 572 g, comprising 244 g stiff, 258 g soft and 70 g crumbly maize meal porridge. While stiff maize meal porridge provided the bulk of cooked maize meal porridge consumed in the study of Oldewage-Theron, Dicks and Napier, soft and stiff porridge was consumed in approximately similar quantities in our study. The average maize meal porridge portion size reported in the South African food consumption studies carried out between 1983 and 2000, was 848 g per person per day.[41] These studies were carried out among different population groups including children (10 years and older) and adults from all ages and ethnic groups in urban and rural areas.[41]

To determine the nutrient composition of raw, unfortified and fortified maize meal as well as different types of maize meal porridge, a study was conducted in 2005 whereby soft, stiff and crumbly porridges were prepared from raw, unfortified and fortified maize meal according to standardised recipes and then chemically analysed.[21] An observation was made that for fortified soft and stiff super maize meal porridges the chemically analysed riboflavin fortified value was lower than the analysed unfortified value.[21] The chemically analysed riboflavin values for raw unfortified and fortified maize meal (from which the porridges were prepared) indicated that the fortified value was higher than the unfortified. It was for this reason that our study could have underestimated the nutrient intake of riboflavin, since the chemically analysed fortified super soft, stiff and crumbly maize meal porridges were used for the dietary intake analysis. The differences could be ascribed to storage, preparation or laboratory analysis of the prepared porridges. There are many factors which could affect the stability of micronutrients in fortified maize products.[42] Riboflavin is very stable during thermal processing, storage, and food preparation, however, is susceptible to degradation on exposure to light.[42] The average cooking losses of riboflavin in super maize meal according to the CSIR report on the stability of fortified food vehicles for the National Food Fortification Programme was reported as negligent. It indicated that riboflavin is not affected by heat as only 8% was lost in special maize meal porridge and it was negligible for super maize meal porridge.[43] Among the six vitamins used for food fortification riboflavin is the most sensitive to light and alkalis[44] and could have had an effect on the analysed values in our study. The error observed regarding the chemically analysed riboflavin value for fortified super soft and stiff maize meal porridge therefore requires evaluation and must be corrected.[21]

The food fortification legislation states that a 200 g serving of raw maize meal should provide persons of 10 years and older with the following percentages of the RDA: vitamin A 31%, thiamine 25%, riboflavin 17%, niacin 25%, vitamin B_6 25%, folate 50%, iron 50% and zinc 20%.[11] Using the South African generated yield factors of 5.71, 2.42 and 1.57 for maize meal[45], a 200 g serving of raw maize meal would be equivalent to 1 142 g soft, 484 g stiff or 314 g crumbly maize meal porridge. A similar yield factor of 2.50 for maize meal, as indicated by The Micronutrient Initiative Advisor, Gary Klugman, yields 500 g cooked maize meal porridge[46], which is approximately the same amount of stiff maize meal porridge when using the MRC generated yield factor.[45] The average portion of 585 g consumed (by those who indicated their age) in this study comprised 257 g soft, 257 g stiff and 71 g crumbly porridge which is equivalent to 45 g, 106 g and 45 g of raw maize meal for soft, stiff and crumbly porridge respectively and amounts to a total of 196 g raw maize meal, which almost meets the 200 g serving as required by legislation. For vitamin A, maize meal did not contribute enough to meet the requirements for both males (20%) and females (24%) as the government recommends a minimum of 31% of the RDA.[11] In this study, super maize meal porridge was used for the intake analysis and the chemically analysed vitamin A content of raw fortified super maize meal was 184 µg RE per 100 g[20,21,25], which is similar to the regulatory requirement of 187 µg RE per 100 g.[11] The average cooking losses of vitamin A in super maize meal according to the CSIR report on the stability of fortified food vehicles for the National Food Fortification Programme was reported as 53%.[43] Fortified soft, stiff and crumbly maize meal porridge retained vitamin A at 11 µg RE, 34 µg RE and 79 µg RE per 100 g which relates to a loss of 94.1%, 81.5% and 57.1% respectively.[20,21,25] This may possibly explain why the RDA for vitamin A, as recommended by the food legislation guidelines, was not met in this study. Maize meal contributed to 58% of the RDA for thiamine for males and females which is more than than the government recommendation of 25%. The government recommends that a minimum of 17% of the RDA for riboflavin should come from fortified maize meal and in this study maize meal contributed to 20% for males and 21% for females. For niacin, it is recommended that 25% of the RDA should be obtained from fortified maize meal and in this study it contributed to 43% for males and 45% females of the RDA. The contribution of maize meal towards folate, zinc and vitamin $B_{6,}$ intake in both gender groups was more than the RDA set out by legislation. The average portion size of cooked maize meal porridge consumed in this study was therefore sufficient to meet the RDA for all micronutrients which form part of the food fortification programme, except for vitamin A in both gender groups and iron in females.

As expected the micronutrient intakes would be higher with the fortified maize meal compared to the unfortified maize meal. A significant ($p<0.0001$) difference was found in all the micronutrient intakes comparing the unfortified versus the fortified maize meal intakes of males and females. The effect of the food fortification programme has also previously been evaluated as part of secondary analyses whereby the impact of food fortification was calculated theoretically.[47] Utilising secondary analyses of their 24-hour recalls, the micronutrient intakes of the participants (n = 3 229), as calculated by secondary analyses, were re-calculated by substituting the nutrient values for maize meal porridge and fortified white and brown bread. In males, the mean nutrient intakes increased to at/above the WHO Recommended Nutrient Intake (RNI) for all nutrients with the exception of folate in urban areas. For females, living in urban areas, thiamine, folate and iron intakes remained below the RNI, while in rural areas only iron remained below the RNI. The average portion of maize meal consumed in the urban areas (772 g) was lower than the amount consumed in the rural areas (907 g).[47] The results of the above-mentioned study were generated from combined databases of previous surveys undertaken in South Africa between 1983 - 2000 and therefore not based on a national survey. Whilst nutrient intakes remained below the RNI, the theoretical exercise also demonstrated how food fortification could make a considerable contribution to the micronutrient intakes of adults.

In this study the effect of employment on maize meal consumption was investigated. The number of unemployed and employed participants in the maize meal consumer group amounted to 212 (9.0%) and 1 546 (65.6%) respectively. The unemployed group classification used in this study did not take into account students, housewives, pensioners or self-employed participants. The official unemployment rate among females in the 2011 Census was 34.6%, while for males it was 25.6%.[48] The findings in our study are in agreement with the 2011 Census as it also showed that a significantly ($p<0.001$) higher percentage of females (70.7%) than males (29.2%) were unemployed. The 2011 Census found that 29.8% of South Africa's population was unemployed[48], whilst in this study it was 9.0% for the maize meal consumer group. Should students, housewives, pensioners or self-employed participants (24.6%) be included in the unemployment group, the figure of unemployment would increase to 33.6%, which would be in line with the 2011 Census findings (29.8%). Unemployed refers to "persons who did not work, but who looked for work and were available to work in the reference period" whereas the unemployment rate is defined as the number of unemployed persons as a percentage of the labour force.[48] The province with the highest unemployment rate according to the 2011 Census was Limpopo (38.9%) followed by Eastern Cape (37.4%), KwaZulu-Natal (33.0%), Free State (32.6%), Mpumalanga (31.6%), North West (31.5%), Northern Cape (27.4%), Gauteng (26.3%) and Western Cape (21.6%).[48] In this study the unemployment rate was ordered differently for the provinces with the highest being Eastern Cape (19.8%), Gauteng (17.9%), KwaZulu-Natal (17.5%), Limpopo (15.1%), Northern Cape (7.6%), Western Cape (7.1%), Free State (6.1%), Mpumalanga (5.7%) and North West (3.3%). Given the difference in unemployment figures in our study (9.0%) compared to the 2011 Census (29.8%), the effect of possible sampling bias is noted resulting from the use of targeting only households which purchased maize, flour or rice in the past month during data collection.

Unemployment has been shown to have an effect on maize meal consumption as a significantly ($p<0.001$) higher amount (696 g, SD = 504 g) of maize meal porridge was consumed by the unemployed group, compared to the employed group (564 g, SD = 519 g). Similarly there was a significantly ($p<0.001$) higher micronutrient intake in the unemployed group for all of the six vitamins (vitamin A, riboflavin, thiamine, folate, niacin, vitamin B_6) and two minerals (iron, zinc) which form part of the fortification premix. For the unemployed maize meal consumers, fortification of maize meal therefore significantly increased the intake of all micronutrients used in the fortification of maize meal. In a study conducted by Oldewage-Theron and Slabbert the extent to which poverty influences the food intake of informal settlement dwellers was investigated.[27] The unemployment rate was 94.2% for respondents and of the 20 food items most frequently consumed, maize meal porridge was consumed by 100% of the households on a regular basis.[27] This illustrates that there are indications that unemployment could play an important role in the amount of maize meal consumed.

In a study undertaken in KwaZulu-Natal, a high prevalence (54%) of unemployment was observed.[49] The aim of that study was to evaluate how effective the food fortification programme was in breastfeeding females (n = 142).[50] Each females' average dietary intake was calculated from five 24-hr recalls collected per female and then used to determine the mean intake for the group. The mean daily intakes of vitamin A (267.4%), folate (139.5%), vitamin B_6 (110.6%), iron (106.0%), riboflavin (100.0%), niacin (70.8%), zinc (43.0%) and thiamine (33.7%) increased significantly ($p<0.001$) from before to after fortification. These vitamins form part of the fortification premix according to the food fortification legislation. Despite the mean intakes, more than 70% of the study group did not meet, the EAR for zinc, vitamin A, riboflavin and vitamin B_6 after fortification.[50]

The effect of poverty was also investigated in this study. "A poverty line is a monetary cut-off point below which a person is deemed to be poor".[28] The cost of the food component alone is usually referred to as the food poverty line. In South Africa, the food poverty line is set at R305 per person per month.[51] Adequate nutrition is considered during the process of deriving at a food poverty line. It is a human basic need and therefore a focal element in the estimation of a food poverty line. In short, the process includes calculating a minimum food-energy requirement and determining a reference food basket which takes into account the numerous food items consumed by the diverse South African households.[28] To distinguish from the food poverty line, the lower-and-upper-bound poverty lines (sometimes referred to as total poverty lines) is set at R416 and R577 respectively and refers to the food poverty line (R305) plus the average amount derived from non-food items of households and provides a range for the total poverty lines.[51] In this study, the national upper-bound poverty line of R577 per capita monthly income (in March 2009 figures) proposed by Statistics South Africa, 2008 was used to take into account the non-food component as well.[28] The Living Conditions Survey (LCS) conducted by Statistics South Africa between September 2008 and August 2009 was the first survey designed to measure poverty and found that 52% of South Africans were living below the upper-bound poverty line of R577 per person per month. Using the 2003 Demographic and Health Survey quotient of four persons per household[29] the number of maize meal consumer households living below the poverty line (using the upper-bound poverty line)[28] in this study amounted to 195 (8.3%) households, which is much lower than the findings of the LCS.[29] The number of households living below the poverty line in the various provinces was as follows: Gauteng 55 (28.2%), KwaZulu-Natal 45 (23.0%), Limpopo 29 (14.8%), North West 22 (11.2%), Eastern Cape 16 (8.2%), Western Cape 12 (6.1%), Free State 9 (4.6%) and Mpumalanga 7 (3.5%) with the Northern Cape (n = 0) not having any household below the poverty line. Since only participants who consumed two of the three grain products (maize, flour, rice) were included for the consumer grain survey, the sampling could have led to sampling bias and the results can therefore not be extrapolated to the South African population, but rather provides information regarding typical maize meal consumers living below the poverty line.

Our study findings indicated that those individuals who did not disclose their HHI was found to consume the same amount (589 g) of maize meal compared to those (584 g) who earned between R6 001 - R8 000 and therefore, the micronutrient intake was also similar for these two groups. Our study findings also indicated that the micronutrient intakes of HHI groups earning R6 000 and more, including the group who did not indicate their HHI, were significantly lower than HHI groups below the poverty line (R2 000 per month). As the HHI increased, the amount of maize meal consumed decreased. The mean intake of folate was 297 µg for HHI groups below the poverty line and almost met the EAR set at 330 µg and 320 µg for 14 - 18 year old and 19 - 70 year old individuals respectively.[15] The HHI group earning over R10 000 consumed the lowest amount of folate (169 µg), thiamine (0.43 mg), riboflavin (0.15 mg), niacin (4.2 mg), vitamin A (111 µg RE), vitamin B_6 (0.407 mg), iron (4.2 mg) and zinc (2.01 mg). Economic growth is usually associated with a change in lifestyle and diet of a population.[30] As a result higher income groups are able to afford a more varied diet. People who do not consume maize as a staple but rather consume a varied/mixed diet will therefore obtain the balance of their micronutrient requirements from other sources in the rest of the diet. While higher income groups may afford to have a more varied diet, they too might be at risk of having inadequate intake of certain micronutrients. In a study conducted in 1995, from a representative sample of 2 000 South African adults, it was shown that the white (65%) and Indian South African (56%) population groups followed a mixed diet (no staple food), while maize was indicated as the staple food for 49% of the black African population and 8% of South Africans of mixed ancestry. The population groups consuming a mixed diet and even those consuming a staple food[30], however, as shown in the study by Langenhoven were found to be low in micronutrients, especially thiamine, riboflavin and vitamin B_6.[34]

In summary the sampling procedure used in the national consumer survey may have had some limitations as only those who consumed maize, rice or flour products were selected for participation in the study. Results from this study therefore differed from other national surveys as the LCS conducted by Statistics South Africa between September 2008 and August 2009 found that 52% of South Africans were living below the upper-bound poverty line of R577 per person per month, while in this study it amounted to 195 (8.3%) households. Additionally, the 2011 Census found that 29.8% of South Africa's population was unemployed[46], whilst in this study it was 9.0% for the maize meal consumer group. Despite the limitations regarding the representativeness of the study sample, the results from the secondary analysis of data provided a good opportunity to calculate the contribution of maize meal to the micronutrient intake of adults and could demonstrate the important role food fortification plays in vulnerable groups such as the unemployed and lower HHI groups in this study, who consumed more maize meal.

4.6. Conclusion

In this study maize meal was an important food item in the diets of the participants as a high percentage (n = 2 356; 84%) of the total population consumed it. In population groups where maize meal is indicated as the staple food, the nutrients supplied by the fortified maize meal could make an important contribution to the intake of micronutrients. The average portion size of cooked maize meal consumed in this study translated to almost 200 g raw maize meal which is in agreement with the amount of maize meal used by the Department of Health to base their fortification guidelines for maize meal on. Most of the recommended fortification micronutrient requirements were therefore met in the population group and it illustrated that food fortification is important and that maize meal makes an important contribution to thiamine, riboflavin, niacin, folate, vitamin B_6, iron and zinc intakes.

This study also highlighted that maize meal is an essential food item in the diets of those who are unemployed as well as those in lower household income groups as they consumed higher amounts than those who are less vulnerable. In these groups the fortification of maize meal plays an important role in providing crucial micronutrients.

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Chapter 5
Summary, conclusion, limitations and recommendations

The aim of the research described in this thesis was to determine the knowledge, attitudes and practices regarding food fortification among mill managers and to determine the contribution of maize meal to the micronutrient intake of a national sample of South African adults.

This last chapter summarises the main findings of the research. The implications of these findings, conclusions and recommendations to consider in future are presented and discussed.

5.1 Summary and discussion

5.1.1 Knowledge, attitudes and practices regarding food fortification among maize meal and wheat flour mill managers in South Africa

In Chapter 3, the aim of this study was to gather information on the knowledge, attitudes and practices regarding food fortification among the maize meal and wheat flour mill managers in South Africa. Staff members responsible for overseeing fortification at maize meal and wheat flour mills in South Africa were recruited for participation in this study. Data were collected by means of a pretested self-administered questionnaire available in English and Afrikaans and distributed to 211 study participants in South Africa via email, post and fax. The response rate was 14.2% (n = 30).

- In the first study (Chapter 3), the overall mean knowledge score of managers regarding food fortification was found to be average (52.2%). A very low percentage (10.0%) of mill managers obtained training regarding food fortification and could possibly explain the average knowledge scores.

- Participants who *strongly agreed* and *agreed* that food fortification of maize meal/wheat flour creates a better quality product had a significantly (p-value 0.011) higher knowledge score than those who *strongly disagreed* or *disagreed.*

- Environmental health practitioners (EHP) has been mandated by the Department of Health (DOH) to monitor mills to ensure compliance with regards to food fortification regulations and sample at the level of milling, just after the fortification premix has been added.[1] Findings of the questionnaire revealed that 40.0% of mills have never been visited by an EHP to monitor whether mills comply with the fortification regulations. In this small sample size it represents almost half of the group which is a concern. The lack of visits to conduct quality control inspections by the EHP may lead to non-compliance. These visits are vital to ensure compliance and successful practices regarding food fortification at the respective mills.

- As stated in Annexure I of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972), manufacturers are required to perform spot checks to ensure that the final product has been dosed correctly by determining one of the components of a fortification premix.[1] In this study only 43.3% of the mills tested the final product at the mill to ascertain whether it was fortified. As mentioned in the strengthening monitoring and compliance report, findings revealed that less than 16% of maize meal samples collected from mills in six provinces complied with the regulations.[2] The level of several key micronutrients added to maize meal and white bread flour were unsatisfactory due to insufficient addition of fortification premix at the mills.[2] These findings confirmed non-compliance with the regulations as was also demonstrated in this study.

5.1.2 The contribution of maize meal to the micronutrient intake in a national sample of South African adults aged 16-88 years old

In the second study (Chapter 4), secondary analysis of data were aimed at determining the contribution of fortified maize meal to the macro-and-micronutrient intake (vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, iron and zinc) as derived from the maize meal consumption of a national sample of South Africans. The South African Food Composition Database[3] was used for the analysis of the maize meal intake data.

- Results of the present study showed that maize meal alone contributed to 75% of the Recommended Dietary Allowance (RDA)[4] for available carbohydrates in maize meal consumers (n = 2 344). Maize meal also contributed more than a quarter (28%) of the AI[4] for dietary fibre and approximately a fifth (21%) of the RDA for protein illustrating the importance of maize meal as a source of these nutrients. Fortified maize meal contributed to 100% of the EAR[5,6] for iron, thiamin and folate for a third (n = 773; 33%), a fifth (n = 483; 20.6%) and 26.5% (n = 621) of the maize meal consumers (n = 2 344) respectively. The fortification of maize meal with these key nutrients therefore makes an important contribution to the micronutrient intakes of individuals.

- The food fortification legislation states that a 200 g serving of raw maize meal should provide persons of 10 years and older with the following percentages of the RDA: vitamin A

31%, thiamine 25%, riboflavin 17%, niacin 25%, vitamin B_6 25%, folate 50%, iron 50% and zinc 20%.[1] The average portion of cooked maize meal of consumers (n = 2 344) in this study was 585 g comprising 257 g of soft and stiff and 71 g crumbly porridge which is equivalent to 45 g, 106 g and 45 g of raw maize meal for soft, stiff and crumbly porridge respectively and amounts to a total of 196 g raw maize meal. This amount, is almost the same as the 200 g serving of fortified maize meal recommended in the food fortification legislation to meet specific micronutrient intake goals.[1] For vitamin A, maize meal did not contribute enough to meet the requirements for both males (20%) and females (24%) as the government aims to achieve a minimum of 31% of the RDA from fortified maize meal.[1,5] Therefore, not all the recommended micronutrient dietary intake requirements regarding fortified maize meal were met in the study population group. Despite this, it illustrated that food fortification is important and that maize meal makes a good contribution to the micronutrient intake.

- The mean portion sizes consumed by the unemployed and employed maize meal consumers were 696 g (SD = 504 g) and 564 g (SD = 519 g) respectively. Maize meal intake of the unemployed maize meal consumers were significantly ($p<0.001$) higher than the employed maize meal consumers. Similarly there was a significantly ($p<0.001$) higher micronutrient intake in the unemployed group for all of the six vitamins (vitamin A, riboflavin, thiamine, folate, niacin, vitamin B_6) and two minerals (iron, zinc), which form part of the fortification premix.

- Vitamin A, thiamin, riboflavin, niacin, vitamin B_6, thiamin, folate, iron and zinc intakes were significantly lower for household income (HHI) categories earning above R6 000 compared to HHI living below the poverty line (R2 000). The results of the study showed that the lower the income of the participants, the higher the amount of maize meal consumed.

5.2 Main conclusions drawn from the study

The sample size of the study in Chapter 3 was small; however, the message from this study is important and indicates shortcomings of the national food fortification process. The overall mean knowledge score of mill managers regarding food fortification was average (52.2%) and requires attention. This study showed that there was a lack of training among mill managers and there are still shortcomings regarding food fortification practices among small and medium sized mills. The current knowledge, attitudes and practices of mill managers towards food fortification indicates the unsatisfactory practices which may be one of the contributing factors to the unsatisfactory level of several key micronutrients in fortified maize meal and wheat flour.

The findings revealed a need for creating awareness among mill managers regarding the training manual which provides simple, easy to read instructions regarding standard procedures to ensure maize meal or wheat flour are fortified adequately.[7] Information could possibly be extrapolated from the manual and used as part of the training activities at the respective mills.

The micronutrient intake of participants based on a theoretical calculation using fortified maize meal values substituted for the unfortified values illustrated that as a result of the fortification of maize meal (Chapter 4), the maize meal consumers had a higher intake of micronutrients which was sufficient enough to meet the food legislation guidelines for all groups except for vitamin A in both gender groups.[1] The fortification of maize meal according to the regulations as set out by the legislation has resulted in maize meal meeting 100% of the EAR for iron, thiamin and folate of nutrients that form part of the national South African food fortification programme for the participants. This data has illustrated the benefits and importance of food fortification.

5.3 Limitations of the study

The following limitations of the study should be noted:

- The small sample size of the study in Chapter 3 is not representative of all mill managers in South Africa, but provides an indication of the present knowledge, attitudes and practices of mill managers. To be more representative of the number of mill managers, the sample size should be increased. Mill managers from especially small and large scale mills should be included. Generally large scale millers are members of the National Chamber of Milling (NCM).[8] The NCM represent the South African flour and maize milling interest. The organisation represents 27% and 40% of the maize and wheat milling market respectively and assists in the common interest of the milling industry in South Africa. For such a study to be successful, these larger scale millers, might participate if endorsement and support is offered by the NCM.[8] Personal visits to managers at the mill site could possibly increase participation and prior arrangements made with the managers about the intended visits should be conducted to ensure managers are reminded and will honour the agreement to be interviewed. The provision of a sizeable travelling budget is an essential requirement for the success of visiting managers personally as mill sites are widespread across the country.

- To the principle researcher’s knowledge a study of a similar nature was conducted by the DOH, however, the information could not be accessed. An embargo was placed on the DOH publication which made it difficult to compare the data of this study to it.[9]

- The time between when managers were identified at the mill and the time at which questionnaires were distributed may have been too long (11 months). Some mills could have closed down during this period and this could possibly explain why 10 companies, which were previously contacted, were unreachable after the questionnaires were distributed. Ethical approval was obtained on 23 November 2010 from Stellenbosch University and 1 April 2011 from the Medical Research Council. Due to personal circumstances the questionnaires could not be distributed immediately after ethical approval was obtained and was therefore only sent out in October 2011.

- A possible limitation of the study in Chapter 4 could be that the data could not be categorised and compared between urban and rural areas to investigate how food fortification benefits the rural communities. This is of great importance since the most vulnerable group consumes diets of poor nutrient density and has been reported to live in rural areas.[10] This study highlighted that unemployed and lower HHI groups consumed more maize meal than those who were employed or were from higher HHI groups.

- In addition the sampling procedure proved to be a possible limitation. The sampling procedure used in the national consumer survey may have had some limitations as only those who consumed maize, rice or flour were selected for participation in the study. Results from this study therefore differ from other national surveys as the Living Conditions Survey conducted by Statistics South Africa between September 2008 and August 2009 found that 52% of South Africans were living below the upper-bound poverty line of R577 per person per month, while in this study it amounted to 195 (8.3%) households. Additionally, the 2011 Census found that 29.8% of South Africa's population was unemployed[11], whilst in this study it was 9.0% for the maize meal consumer group. Despite this the results from the secondary analyses of data provided a good opportunity to calculate the contribution of maize meal to the micronutrient intake of adults and could demonstrate the important role food fortification plays in vulnerable groups such as the unemployed and lower HHI categories in this study, who consumed more maize meal.

5.4 Recommendations

- Forty percent of the mills indicated that they have never been visited by an EHP. This information should be communicated to the DOH by the millers themselves or possibly by the NCM.

- Each mill manager indicated from which manufacturer or supplier or importer the mills' fortification premix was obtained. Considering the registered suppliers for 2011 and 2012[12] alone, only 58.3% (n = 14) of the 24 mills who responded to that question were registered. According to the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972) manufacturers of food vehicles may only obtain fortification premixes from companies that have registered with the DOH.[1] This indicates non-compliance of the manufacturers and presents an opportunity to investigate why non-registered suppliers are being used. This finding was also found to be in agreement with that of Sunley and Umunna[13] from interviews conducted by them. Additionally a concern regarding the quality of the vitamin A used in the fortification premix relating to the stability was raised.[13]

- Findings from this study could be used to improve the various sources of food fortification used by mill managers, which will in turn improve their knowledge and may impact on their attitudes and practices.

- The chemically analysed values for raw unfortified and fortified super maize meal were correct.[3] There are concerns though regarding the riboflavin value for fortified super soft and stiff maize meal porridge as the chemically analysed value for riboflavin for fortified super maize meal porridge was lower than the unfortified value[3] and it is suggested to investigate the reasons for these differences in the values. The energy and nutrient content of combined dishes can be estimated by using a theoretical recipe calculation procedure based on the ingredients of the recipe.[14] During preparation and cooking there are changes which affect both the weight (yield factor) of the ingredients and nutrient contents of the ingredients (retention factor) in the recipe. The recipe calculation procedure takes the yield and retention factors into account when a new nutrient value for a food item is calculated. It is therefore recommended that should the chemical re-analysis of the maize meal not be possible, the use of the appropriate EUROFIR recipe calculation procedure is considered for recalculating new values for riboflavin.[14]

5.5 References

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Addendum 1: Questionnaire to the manager in English

Code number: office use | | | |

QUESTIONNAIRE REGARDING FOOD FORTIFICATION

Food fortification is essential for the health of all South Africans, because most are at risk of getting insufficient micronutrients from our diets.

Herewith I kindly request your participation in this research project.

Participation is, however, voluntary. Your response is confidential and will be dealt with as such. Should you wish to receive feedback on the outcome of the study, please provide your contact details on the questionnaire? By completing this questionnaire you consent to partaking in this study.

There are 45 questions and different types of answers required in this questionnaire. With some you only need to tick the appropriate box, while with others you might need to write in an answer.

Date questionnaire was completed:______________________

Section A. General information:

Do you wish to receive feedback on the results of this questionnaire? [Yes] [No]

If YES, kindly provide the contact details to which the feedback should be sent:

1.1 Name (optional if NO):_____________________________

1.2 Email address (optional if NO):_______________________

1.3 Telephone number (optional if NO):___________________

1.4 Fax number (optional if NO):_________________________

1.5 What is your current age? ______________________Years.

1.6 Gender: (Tick one)

1.6.1 Male [ ]

1.6.2 Female [ ]

1.7. What is your current position in the organisation?:

____

1.8 Highest Qualification obtained: (Tick one)

1.8.1 Before grade 12 [ ]

1.8.2 Grade 12 [ ]

1.8.3 Diploma / Certificate [ ]

1.8.4 Degree [ ]

1.8.5 Post-graduate qualification [ ]

1.8.6 Other, please specify _______________________________

1.9 Which province/s do you work in: (Tick the relevant box/boxes)

1.9.1 Eastern Cape [ ]
1.9.2 Gauteng [ ]
1.9.3 Free State [ ]
1.9.4 Limpopo [ ]
1.9.5 Northern Cape [ ]
1.9.6 North West Province [ ]
1.9.7 KwaZulu-Natal [ ]
1.9.8 Mpumalanga [ ]
1.9.9 Western Cape [ ]

1.10 Please specify the area in the province in which you work:

1.11 Is your organisation registered with the National Chamber of Milling?:

____

Section B.

1. Please indicate the number of employees working at the mill (include permanent and part-time):

____

2. How many days of the year is the mill in operation?

____

3. How many hours per day is the mill in operation?

____

4. What is the milling capacity of the mill: (Tick one)

4.1 Small (Less than 1 Ton/hr)	[ ]
4.2 Medium (1 to 3 Ton/hr)	[ ]
4.3 Large (More than 2 Ton/hr)	[ ]

5. Please indicate the type of grain milled at the mill: (Tick the relevant boxes)

5.1 Maize	[ ] If only maize is milled, go to Question 6
5.2 Wheat	[ ] If only wheat is milled, go to Question 7
5.3 Both maize and wheat	[ ] If both are milled, answer Questions 6 & 7

5.4 Other, please specify ______________________________

6. How many tons of maize meal is produced daily?:

____

7. How many tons of wheat flour is produced daily?:

____

Section C.

1. Since when is food fortification mandatory in South Africa?: (Tick one)

1.1	1993	[ ]
1.2	1997	[ ]
1.3	2003	[ ]
1.4	2005	[ ]
1.5	Unsure	[ ]
1.6 Other, please specify:		____________________

2. Which **vitamins** are used to fortify maize meal in South Africa?: (Tick one)

2.1 Thiamin, Riboflavin, Niacin, Vitamin C, Vitamin A, Vitamin D	[ ]
2.2 Vitamin D, Thiamin, Folate, Riboflavin, Niacin, Vitamin A	[ ]
2.3 Niacin, Thiamin, Folic acid, Riboflavin, Vitamin A, Pyridoxine	[ ]
2.4 Unsure	[ ]
2.5 None of the above	[ ]

3. Which **minerals** are used to fortify maize meal in South Africa?: (Tick one)

3.1 Magnesium & Selenium	[ ]
3.2 Calcium & Manganese	[ ]
3.3 Zinc & Iron	[ ]
3.4 Iron & Calcium	[ ]
3.5 Unsure	[ ]
3.6 None of the above	[ ]

4. Which **vitamins** are used to fortify wheat flour in South Africa?: (Tick one)

4.1 Thiamin, Riboflavin, Niacin, Vitamin C, Vitamin A, Vitamin D	[ ]
4.2 Vitamin D, Thiamin, Folate, Riboflavin, Niacin, Vitamin A	[ ]

4.3 Niacin, Thiamin, Folic acid, Riboflavin, Vitamin A, Pyridoxine [ ]

4.4 Unsure [ ]

4.5 None of the above [ ]

5. Which **minerals** are used to fortify wheat flour in South Africa?: (Tick one)

5.1 Magnesium & Selenium [ ]

5.2 Calcium & Manganese [ ]

5.3 Zinc & Iron [ ]

5.4 Iron & Calcium [ ]

5.5 Unsure [ ]

5.6 None of the above [ ]

6. What are the benefits of food fortification?:

____

7. Why is maize meal and wheat flour being fortified in South Africa?:

____

8. For what period of time will food fortification of maize meal and wheat flour still continue in South Africa?: (Tick one)

8.1 Until 2011 [ ]

8.2 Until all micronutrient deficiencies are eradicated in South Africa [ ]

8.3 It will continue forever [ ]

8.4 Unsure [ ]

8.5 Other, please specify ______________________________

9. Food fortification is the only method of addressing micronutrient deficiencies: (Tick one)

9.1 True [ ]

9.2 False [ ]

9.3 Unsure [ ]

Section D.

1. <u>Food fortification of maize meal/wheat flour at the mills demands a lot of time and extra work from the staff</u>: (Tick one)

1.1 Strongly agree [ ]
1.2 Agree [ ]
1.3 Disagree [ ]
1.4 Strongly disagree [ ]

2. <u>Food fortification costs the mill a lot of money which could have been spent on other needs</u>: (Tick one)

2.1 Strongly agree [ ]
2.2 Agree [ ]
2.3 Disagree [ ]
2.3 Strongly disagree [ ]

3. <u>The fortification premix, which the mill has to buy, is too expensive:</u> (Tick one)

3.1 Strongly agree [ ]
3.2 Agree [ ]
3.3 Disagree [ ]
3.4 Strongly disagree [ ]

4. <u>The Environmental Health Officers, should visit the mill regularly to check whether the regulations are being complied with: (Tick one)</u>

4.1 Strongly agree [ ]
4.2 Agree [ ]
4.3 Disagree [ ]
4.4 Strongly disagree [ ]

5. The monthly records of the amount of fortification premix added to maize meal/wheat flour creates a lot of paperwork: (Tick one)

5.1 Strongly agree [ ]
5.2 Slightly agree [ ]
5.3 Disagree [ ]
5.4 Strongly disagree [ ]

6. The fortification of maize meal/wheat flour creates a better quality product: (Tick one)

6.1 Strongly agree [ ]
6.2 Agree [ ]
6.3 Disagree [ ]
6.4 Strongly disagree [ ]

7. Food fortification is essential for the nutritional well-being of all South Africans: (Tick one)

7.1 Strongly agree [ ]
7.2 Agree [ ]
7.3 Disagree [ ]
7.4 Strongly disagree [ ]

Section E.

1. Have you modified your milling enterprise to comply with the maize meal fortification legislation?: (Tick one)

1.1 Yes [ ] If YES, go to Question 2
1.2 No [ ] If NO, go to Question 3

2. What modifications have you implemented at your mill?:

3. Why have you not modified your mill?;

4. Fortification is conducted by means of: (Tick one)

4.1 Two-stage mixing [ ]
4.2 Batch mixing [ ]
4.3 Continuous mixing [ ]
4.4 Unsure [ ]
4.5 Other please specify: ____________________

5. Where do you obtain your premix from: (Tick one)

5.1 Chempure [ ]
5.2 AB Mauri [ ]
5.3 Avi-Pharm Natal [ ]
5.4 Unsure [ ]
5.5 Other, please specify ____________________

6. The premix is stored according to: (Tick one)

6.1 Instructions given by the manager [ ]
6.2 Storage instructions are not needed [ ]
6.3 Instructions on the packaging [ ]
6.4 Instructions given by the supplier [ ]
6.5 Standard in-house procedures followed daily [ ]
6.6 Other, please specify ____________________

7. <u>The premix can be stored under any conditions as long as the packet is closed</u>: (Tick one)

7.1 Yes	[ ]
7.2 No	[ ]
7.3 Unsure	[ ]

8. <u>Does the mill have back-up premix packets at any given time, should the current stock become expired or damaged</u>: (Tick one)

8.1 Yes	[ ]
8.2 No	[ ]
8.3 Unsure	[ ]

8.4 If yes, where is it stored? ______________________________

9. <u>Are the temperature conditions of the premix monitored</u> (Tick one)

9.1 Yes	[ ] If YES, go to question 7
9.2 No	[ ] If NO, go to question 8.
9.3 Unsure	[ ]

10. How is the temperature conditions of the premix monitored?

____

11. <u>Are the expiry dates of the premix monitored</u> (Tick one)

11.1 Yes	[ ] If YES, go to question 9.
11.2 No	[ ] If NO, go to question 10.
11.3 Unsure	[ ]

12. <u>How is the expiry date of the premix monitored</u>?

____

13. At which rate is the fortificant mix added to the maize meal/wheat flour: (Tick one)

13.1 One hundred gram per ton of food vehicle [ ]
13.2 One hundred and fifty gram per ton of food vehicle [ ]
13.3 Two hundred gram per ton of food vehicle [ ]

13.4 Two hundred and fifty gram per ton of food vehicle [ ]
13.5 Unsure [ ]

14. How regularly does an Environmental Health Officer visit the mill to monitor fortification to determine whether the mill complies with the regulations?:

14.1 Every month [ ]
14.2 Every six months [ ]
14.3 Once a year [ ]
14.4 Every second year [ ]
14.5 Never

15. Are tests conducted at the mill to determine if the maize meal/wheat flour is fortified: (Tick one)

15.1 Yes [ ] If YES, got to question 13.
15.2 No [ ]
165.3 Unsure [ ]
15.4 Never

16. Please indicate which type of test is used at the mill to determine if maize meal/wheat flour is fortified: (Tick one)

16.1. Iron spot test [ ]
16.2 Flourescence test [ ]
16.3 Chemical analysis [ ]
16.4 Unsure [ ]
16.5 Other, please specify ________________________________

17. <u>How regularly are these tests conducted on the fortified maize meal/wheat flour?</u>: (Tick one)

17.1 Thrice every 8 hour shift [ ]
17.2 Once every 8 hour shift [ ]
17.3 Twice every 8 hour shift [ ]
17.4 Unsure [ ]
17.5 Never
17.6 Other, please specify ________________________

18. <u>Are tests conducted on the premix to determine if it meets the requirements?</u>:
(Tick one)

18.1 Yes [ ] If YES, got to question 16.
18.2 No [ ]
18.3 Unsure [ ]
18.4 Never [ ]

19. <u>How regularly are these tests conducted on the premix?</u>: (Tick one)

19.1 Thrice every 8 hour shift [ ]
19.2 Once every 8 hour shift [ ]
19.3 Twice every 8 hour shift [ ]
19.4 Unsure [ ]
19.5 Never [ ]

Section F:

1. Please indicate where you receive information on Food Fortification from: (Tick the relevant boxes)

1.1 Television [ ]
1.2 Department of Health [ ]
1.3 National Chamber of Milling [ ]
1.4 South African Grain Information Services [ ]
1.5 South African Grain Silo [ ]
1.6 Environmental Health Officers [ ]
1.7 Fortification workshops [ ]
1.8 In-house training/sources [ ]
1.9 Internet [ ]
1.10 Other, please specify [ ]

2. Have you undergone any training regarding the food fortication legislation? (Tick one)
2.1 YES [ ] If YES, go to Question 3
2.1 NO [ ] If NO, go to Question 5

3. Who provided the training?

____

4. What were the main areas you were trained in?

____

5. Why have you not undergone any training?

____

6. Would you like to receive training or information regarding food fortification legislation?

____

Thank you for your time and participation!!

Addendum 2: Questionnaire to the manager in Afrikaans

Kodenommer: Kantoorgebruik

VRAELYS OOR FORTIFISERING

Voedselfortifisering is belangrik vir die gesondheid van alle Suid-Afrikaners, omdat die meeste mense die risiko loop om te min mikronutriënte van hul dieët te kry.

Ek versoek hiermee vriendelik u deelname aan hierdie navorsingsprojek.

Deelname is egter vrywillig en u respons sal as vertroulik hanteer word. Deur hierdie vraelys te voltooi, stem u in om deel te neem aan hierdie studie.

Daar is 45 vrae en verskillende tipe antwoorde wat in die vraelys verlang word. Met sommige hoef u net die toepaslike blokkie te merk, terwyl met ander moet 'n antwoord ingeskryf word.

Datum wat vraelys voltooi is: ________________________

Afdeling A: Algemene inligting

Verlang u terugvoering ten opsigte van die resultate van hierdie vraelys? [Ja] [Nee]

Indien JA, voorsien asseblief u kontak besonderhede waarheen die terugvoering gestuur moet word:

1.1 Naam (opsioneel indien NEE): ________________________

1.2 E-pos adres: (opsioneel indien NEE): _________________

1.3 Telefoonnommer: (opsioneel indien NEE): ____________

1.4 Faksnommer (opsioneel indien NEE): ___________________

1.5 U huidige ouderdom: _________________________Jare

1.6 Geslag: (Merk een)

1.6.1 Manlik [ ]

1.6.2 Vroulik [ ]

1.7 Wat is u huidige posisie in die organisasie?

____

1.8 Hoogste kwalifikasie: (merk een)

1.8.1 Minder as graad 12 [ ]

1.8.2 Graad 12 [ ]

1.8.3 Diploma/ Sertifikaat [ ]

1.8.4 Graad [ ]

1.8.5 Nagraadse kwalifikasie [ ]

1.8.6 Ander (spesifiseer asseblief)

____

1.9 In watter provinsie/s werk u: (merk waar toepaslik)

1.9.1 Oos-Kaap [ ]

1.9.2 Gauteng [ ]

1.9.3 Vrystaat [ ]

1.9.4 Limpopo [ ]

1.9.5 Noord-Kaap [ ]

1.9.6 Noord-Wes Provinsie [ ]

1.9.7 KwaZulu-Natal [ ]

1.9.8 Mpumalanga [ ]

1.9.9 Wes-Kaap [ ]

1.10 Spesifiseer asseblief die area in die provinsie waarin u werk:

____

1.11 Is u organisasie met die Nasionale meulenaarskamer geregistreer?:

____

Afdeling B.

1. Dui asseblief aan die aantal werknemers wat by die meule werk (insluitend permanente en kontrak werknemers):

____

2. Hoeveel dae van die jaar is die meule in werking?

____

3. Hoeveel uur per dag is die meule in werking?

____

4. <u>Wat is die kapasiteit van die meule</u>: (merk een)

4.1 Klein (Minder as 1Ton/uur) [ ]

4.2 Medium (1-3 Ton/uur) [ ]

4.3 Groot (Meer as 2 Ton/uur) [ ]

5. <u>Dui asseblief aan die tipe graan wat by die meule gemaal word</u>:
(merk die toepaslike blokkie/s)

5.1 Mieliemeel [ ] Indien net mieliemeel gemaal word, gaan na Vraag 6

5.2 Koring [ ] Indien net koring gemaal word, gaan na Vraag 7

5.3 Beide mieliemeel en koring [ ] Indien beide gemaal word, beantwoord Vrae 6 & 7

5.4 Ander (spesifiseer asseblief) _______________________________

6. <u>Hoeveel ton mieliemeel word daagliks geproduseer</u>?:

____

7. <u>Hoeveel ton koringmeel word daagliks geproduseer</u>?:

Afdeling C.

1. Vanaf wanneer is voedselfortifisering verpligtend in Suid-Afrika?: (merk een)

1.1 1993 [ ]
1.2 1997 [ ]
1.3 2003 [ ]
1.4 2005 [ ]
1.5 Onseker [ ]
1.6 Ander (spesifiseer asseblief):

____

2. Met watter **vitamiene** word mieliemeel in Suid-Afrika gefortifiseer?: (merk een)

2.1 Tiamien, Riboflavien, Niasien, Vitamien C, Vitamien A, Vitamien D [ ]
2.2 Vitamien D, Tiamien, Folaat, Riboflavien, Niasien, Vitamien A [ ]
2.3 Niasien, Tiamien, Foliensuur, Riboflavien, Vitamien A, Piridoksien [ ]
2.4 Onseker [ ]
2.5 Geeneen van bogenoemde [ ]

3. Met watter **minerale** word mieliemeel in Suid-Afrika gefortifiseer?: (merk een)
3.1 Magnesium & Selenium [ ]
3.2 Kalsium & Selenium [ ]
3.3 Sink & Yster [ ]
3.4 Yster & Kalsium [ ]
3.5 Onseker [ ]
3.6 Geeneen van bogenoemde [ ]

4. Met watter **vitamiene** word koringmeel in Suid-Afrika gefortifiseer?: (merk een)
4.1 Tiamien, Riboflavien, Niasien, Vitamien C, Vitamien A, Vitamien D [ ]
4.2 Vitamien D, Tiamien, Folaat, Riboflavien, Niasien, Vitamien A [ ]
4.3 Niasien, Tiamien, Foliensuur, Riboflavien, Vitamien A, Piridoksien [ ]
4.4 Onseker [ ]
4.5 Geeneen van bogenoemde [ ]

5. <u>Met watter **minerale** word mieliemeel in Suid-Afrika gefortifiseer</u>?: (merk een)

5.1 Magnesium & Selenium [ ]

5.2 Kalsium & Selenium [ ]

5.3 Sink & Yster [ ]

5.4 Yster & Kalsium [ ]

5.5 Onseker [ ]

5.6 Geeneen van bogenoemde [ ]

6. <u>Wat is die voordele van voedselfortifisering</u>?:

____

7. <u>Hoekom word mieliemeel en koringmeel in Suid-Afrika gefortifiseer</u>?

____

8. <u>Vir hoe lank sal die fortifisering van mieliemeel en koringmeel in Suid-Afrika voortduur</u>? (merk een)

8.1 Tot 2011 [ ]

8.2 Totdat alle mikronutrient tekorte in Suid-Afrika uitgewis is [ ]

8.3 Dit sal vir altyd aanhou [ ]

8.4 Onseker [ ]

8.5 Ander (spesifiseer asseblief)

____

9. <u>Voedelfortifisering is die enigste manier waarop mikronutrient tekorte aangespreek kan word</u> (merk een)

9.1 Waar [ ]

9.2 Vals [ ]

9. Onseker [ ]

Afdeling D.

1. Fortifisering van mieliemeel/koringmeel by die meule vereis baie tyd en eksta werk van die personeel (merk een)

1.1 Stem sterk saam [ ]
1.2 Stem saam [ ]
1.3 Stem nie saam nie [ ]
1.4 Stem glad nie saam nie [ ]

2. Voedselfortifisering kos die meule baie geld wat eerder op ander behoeftes gespandeer kon word (merk een)

2.1 Stem sterk saam [ ]
2.2 Stem saam [ ]
2.3 Stem nie saam nie [ ]
2.4 Stem glad nie saam nie [ ]

3. Die fortifiseringsmengsel, wat die meule moet aankoop, is te duur: (merk een)

3.1 Stem sterk saam [ ]
3.2 Stem saam [ ]
3.3 Stem nie saam nie [ ]
3.4 Stem glad nie saam nie [ ]

4. Die Omgewings-Gesondheid Beamptes behoort die meule op ‘n gereelde basis te besoek om toe te sien dat die regulasies toegepas word (merk een)

4.1 Stem sterk saam [ ]
4.2 Stem saam [ ]
4.3 Stem nie saam nie [ ]
4.4 Stem glad nie saam nie [ ]

5. Die maandelikse rekordhouding ten opsigte van die hoeveelheid van die fortifiseringsmengsel wat by die mieliemeel/ koringmeel gevoeg word, skep baie papierwerk (merk een)

5.1 Stem sterk saam [ ]
5.2 Stem saam [ ]
5.3 Stem nie saam nie [ ]
5.4 Stem glad nie saam nie [ ]

6. <u>Die fortifisering van mieliemeel/koringmeel het 'n beter kwaliteit produk tot gevolg</u> (merk een)

6.1 Stem sterk saam [ ]

6.2 Stem saam [ ]

6.3 Stem nie saam nie [ ]

6.4 Stem glad nie saam nie [ ]

7. <u>Voedselfortifisering is noodsaaklik vir die voedings-welstand van alle Suid-Afrikaners</u> (merk een)

7.1 Stem sterk saam [ ]

7.2 Stem saam [ ]

7.3 Stem nie saam nie [ ]

7.4 Stem glad nie saam nie [ ]

Afdeling E.

1. Is u meul verander om te voldoen aan die fortifiseringwetgewing? (merk een)

1.1 JA [ ] Indien JA, gaan na Vraag 2

1.2 NEE [ ] Indien NEE, gaan na Vraag 3

2. Watter veranderinge het u aan die meul aangebring?:

____

3. Hoekom het u nie veranderinge aan u meul aangebring nie?:

____

41. <u>Fortifisering word gedoen deur middel van</u>: (merk een)

4.1 Twee-stadium vermenging [ ]

4.2 Bondel vermenging [ ]

4.3 Volgehoue vermenging [ ]

4.4 Onseker [ ]

4.5 Ander (spesifiseer asseblief)

____

5. <u>Waar kry u u voormengsel vandaan</u>?

5.1 Chempure [ ]

5.2 AB Mauri [ ]

5.3 Avi-Pharm Natal [ ]

5.4 Onseker [ ]

5.5 Ander, spesifiseer asseblief

____

6. Die voormengsel word gestoor volgens:

6.1 Instruksies van die bestuuder [ ]

6.2 Instruksies vir storing is nie nodig nie [ ]

6.3 Instruksies op die verpakking [ ]

6.4 Instruksies van die verskaffer [ ]

6.5 Standaard prosedures wat daagliks gevolg word [ ]

6.6 Ander (spesifiseer asseblief)

____

7. Die voormensel kan onder enige toestand/ omstandighede gestoor word solank die houer goed toegemaak is (merk een)

7.1 Ja [ ]

7.2 Nee [ ]

7.3 Onseker [ ]

8. Het die meule ten alle tye ekstra voormengsel voorraad sou die huidige voorraad verval of beskadig word

8.1 Ja [ ]

8.2 Nee [ ]

8.3 Onseker [ ]

8.4 Indien ja, waar word dit gestoor?

____

9. Word die temperatuur kondisies waaronder die voormengsel gestoor word, gemonitor (merk een)

9.1 Ja [ ] Indien JA, gaan na vraag 7

9.2 Nee [ ] Indien NEE, gaan na vraag 8.

9.3 Onseker [ ]

10. Hoe word die temperatuur kondisies van die voormengsel gemonitor?

____

11. Word die vervaldatums van die voormengsel gemonitor? (merk een)

11.1 Ja [ ] Indien JA, gaan na vraag 9

11.2 Nee [ ] Indien NEE, gaan na vraag 10

11.3 Onseker [ ]

12. Hoe word die vervaldatum van die voormengsel gemonitor?

____

13. Teen watter tempo word die fortifiserings-mengsel by die mieliemeel/koringmeel gevoeg? (merk een)

13.1 Een honderd gram per ton van die voedsel-draer [ ]

13.2 Een honderd en vyftig gram per ton van die voedsel-draer [ ]

13.3 Twee honderd gram per ton van die voedsel-draer [ ]

13.4 Two honderd en vyftig gram per ton van voedsel draer [ ]

13.5 Onseker [ ]

14. Hoe gereeld besoek die Gesondheids Amptenare die meule om die fortifisering te monitor en om te bepaal of die meule die regulasies toepas?

14.1 Elke maand [ ]

14.2 Elke ses maande [ ]

14.3 Een keer per jaar [ ]

14.4 Elke tweede jaar [ ]

14.5 Nooit [ ]

15. Word toetse by die meule gedoen om vas te stel of die mieliemee/ koringmeel wel gefortifiseer is? (merk een)

15.1 Ja [ ] Indien JA, gaan na vraag 13.

15.2 Nee [ ]

15.3 Onseker [ ]

16. Dui asseblief aan watter tipe toets by die meule gebruik word om vas te stel of die mieliemeel / koringmeel gefortifiseer is: (merk een)

16.1 Yster spot toets [ ]

16.2 Fluorosensie toets [ ]

16.3 Chemiese analiese [ ]

16.4 Onseker [ ]

16.5 Ander, spesifiseer asseblief

____

17. Hoe gereeld word die toetse uitgevoer op die gefortifiseerde mieliemeel/koringmeel? (merk een)

17.1 Drie maal tydens elke 8 uur skof [ ]

17.2 Een maal tydens elke 8 uur skof [ ]

17.3 Twee maal tydens elke 8 uur skof [ ]

17.4 Onseker [ ]

17.5 Nooit [ ]

17.6 Ander, spesifiseer asseblief.

____

18. Word toetse gedoen op die voormengsel om vas te stel of dit aan die vereistes voldoen word?

18.1 Ja [ ] Indien JA, gaan na vraag 16.

18.2 Nee [ ]

18.3 Onseker [ ]

18.4 Nooit [ ]

19. Hoe gereeld word die toetse op die voormengsel gedoen? (merk een)

19.1 Drie keer elke 8 uur skof [ ]

19.2 Een keer elke 8 uur skof [ ]

19.3 Twee keer elke 8 uur skof [ ]

19.4 Onseker [ ]

Afdeling F:

1. Dui asseblief aan waar u inligting ten opsigte van voedsel-fortifisering vandaan kry? (merk die toepaslike blokkie)

1.1 Televisie [ ]

1.2 Departement van Gesondheid [ ]

1.3 Nasionale Meulenaarskamer [ ]

1.4 Suid-Afrikaanse Graan Inligtingsdiens [ ]

1.5 Suid-Afrikaanse Graan Silo [ ]

1.6 Omgewings Gesondheids Amptenare [ ]

1.7 Werksessies oor fortifisering [ ]

1.8 Binnemuurse opleding/bronne [ ]

1.9 Internet [ ]

1.10 Ander, spesifiseer asseblief

---

2. Het u al opleiding ontvang omtrent die voedselfortifiseringwetgewing? (merk een)

2.1 JA [ ] Indien JA, gaan na Vraag 3

2.2 NEE [ ] Indien NEE, gaan na Vraag 5

3. Wie het die opleiding aangebied?

____

4. Watter was die hoofareas waarin u opgelei was?

____

5. Hoekoem het u nie opleiding ontvang nie?

____

6. Wil u graag opleiding of informasie ontvang met betrekking tot die voedselfortifiseringwetgewing?

____

Dankie vir u tyd en deelname!!

Addendum 3: Letter to the manager in English

Date:

Dear Mr/Mrs

QUESTIONNAIRE ABOUT THE FORTIFICATION OF MAIZE MEAL AND WHEAT FLOUR IN SOUTH AFRICA

A few years ago food fortification was implemented in South Africa to combat micronutrient deficiencies. The Nutritional Intervention Research Unit (NIRU) of the South African Medical Research Council (MRC) is undertaking a research project on food fortification and requires your assistance.

The aim of this project is to: (i) chemically analyse fortified maize meal and wheat flour to determine the nutrient content for inclusion of the information in the South African Food Composition Database (SAFOODS); (ii) gather information on food fortification, by means of a questionnaire, from those working in the maize and wheat milling industry in South Africa.

Herewith I wish to kindly request your participation in this research project. I would appreciate it, if you could offer a few minutes of your time to complete the attached questionnaire. The information gathered will assist in providing a better understanding of the advantages of food fortification and the challenges faced by the food industry responsible for food fortification.

The questionnaire consists of a section on general information, open-ended questions as well as a few knowledge, attitudes and practice questions. It should take approximately 10-15 minutes to complete the questionnaire.

The research project has received ethics approval from the Committee for Human Research, Faculty of Health Sciences, University of Stellenbosch.

Participation is voluntary and strictly confidential and should your response be received via email, your email address will be de-linked from your response upon receipt ensuring anonymity. Completion of the form implies informed consent and therefore signing of a consent form is not necessary.

Should you wish to receive feedback on the outcome of the study, please provide your contact details on the questionnaire? The findings of the study will be published in a scientific journal and also used as part of a Masters thesis.

Kindly complete the questionnaire and e-mail it back to Natasha Danster at (natasha.danster@mrc.ac.za) or post it back in the prepaid envelope by......... 2011.

Should you wish to contact me, please see my contact details below?

Your participation will be immensely appreciated. I look forward to your positive response.

Yours Sincerely,

……………………………………..

Contact details:
Natasha Danster
Project Leader
Medical Research Council
Nutritional Intervention Research Unit
PO Box 19070
Tygerberg
7505
Tel: 021 938 0405
Fax: 021 938 0321
E-mail: natasha.danster@mrc.ac.za

Contact details of the MRC Ethics Committee: Prof Danie du Toit 021 938 0341; Email: adri.labuschagne@mrc.ac.za

Addendum 4: Letter to the manager in Afrikaans

Datum:

Geagte Mnr/Mev

VRAELYS OOR DIE FORTIFISERING VAN MIELIEMEEL EN KORINGMEEL IN SUID AFRIKA

Voedselfortifisering is ’n paar jaar gelede in Suid Afrika in werking gestel om mikronutriëntgebreke te bekamp. Die Voedingsintervensie Navorsingseenheid (VINE) van die Suid-Afrikaanse Mediese Navoersingsraad (MNR) onderneem tans ’n navorsingsprojek oor voedselfortifisering en benodig u hulp.

Die doel van die projek is om: (1) gefortifiseerde mielie- en koringmeel chemies te analiseer om die nutriëntinhoud te bepaal vir insluiting in die Suid Afrikaanse Voedselsamestellings Databasis (SAFOODS); (ii) inligting oor voedselfortifisering in te samel, deur middel van ’n vraelys, vanaf diegene wat in die mielie- en koringmeule-industrie in Suid Afrika werk.

Hiermee will ek u graag uitnooi om deel te neem aan die navorsingsprojek. Ek sal dit waardeer indien u ’n paar minute van u tyd kan afstaan om die aangehegde vraelys te voltooi. Die inligting wat ingesamel word sal help om ’n beter begrip te kry van die voordele van voedselfortifisering en die uitdagings wat deur die voedselindustrie in die gesig gestaar word.

Die vraelys bestaan uit ’n afdeling met algemene inligting, oop vrae, sowel as ’n paar kennis, houding en handelinge vrae. Dit sal ongeveer 10-15 minute neem om die vraelys te voltooi.

Die navorsingsprojek het etiese goedkeuring van die Komitee vir Menslike Navorsing, Fakulteit Gesonheidswetenskap, Universiteit van Stellenbos ontvang.

Deelname is vrywillig and streng vertroulik en sou u antwoord per e-pos ontvang word sal u e-pos adres ontkoppel word met ontvangs ten einde anonimiteit te verseker. Voltooing van die vorm beteken dat u ingeligte toestemming gee en daarom is die teken van ’n vrywaringsvorm nie nodig nie.

Indien u terugvoer oor die uitkoms van die projek verwag moet u asseblief u kontak inligting op die vraelys verskaf. Die bevindings van die studies al in ’n wetenskaplike tydskrif en ook as deel van ’n M-tesis gepubliseer word.

Voltooi asseblief die vraelys en stuur dit per e-pos terug na Natasha Danster by natasha.danster@mrc.ac.za of pos dit terug in die voorafbetaalde koevert teen…… 2011.

Indien u my wil kontak, vind asseblief my kontak besonderhede onderaan die brief.

U deelname sal ontsaglik waardeer word. Ons sien uit na ’n positiewe respons.

Die uwe,

Kontak besonderhede:

Natasha Danster
Projekleier
Mediese Navorsingsraad
Voedingsintervensie Navorsingseenheid
Posbus 19070
Tygerberg
7505

Tel: 021 938 0405
Faks: 021 938 0321
E-pos: natasha.danster@mrc.ac.

Kontakbesonderhede van die MNR Etiese Kommittee: Prof Danie du Toit 021 938 0341; E-pos: adri.labuschagne@mrc.ac.za

Addendum 5: Information leaflet

Evaluation of the micronutrient content of South African fortified maize meal and wheat flour sold at retail level

Dear mill manager
Researchers at the Nutritional Intervention Research Unit (NIRU) of the South African Medical Research Council (MRC) are undertaking a research project on food fortification and require your assistance.

Why am I doing the study?
The aim of this project is to: (i) chemically analyse fortified maize meal and wheat flour to determine the nutrient content for inclusion of the information in the South African Food Data System (SAFOODS); (ii) gather information on food fortification, by means of a questionnaire, from those working in the maize and wheat milling industry in South Africa.

What do I expect from participants during the study?
Herewith I wish to kindly request your participation in this research project. I would appreciate it, if you could offer a few minutes of your time to complete the attached questionnaire. The information gathered will assist in providing a better understanding of the advantages of food fortification and the challenges faced by the food industry responsible for food fortification.

The questionnaire consists of a section on general information, open-ended questions as well as a few knowledge, attitudes and practice questions. It should take approximately 10-15 minutes to complete the questionnaire.

Participation is voluntary and strictly confidential and should your response be received via email, your email address will be de-linked from your response upon receipt ensuring anonymity. Completion of the form implies informed consent and therefore signing of a consent form is not necessary.

Should you wish to receive feedback on the outcome of the study, please provide your contact details on the questionnaire? The findings of the study will be published in a scientific journal and also used as part of a Masters thesis.

Kindly complete the questionnaire and e-mail it back to Natasha Danster at (natasha.danster@mrc.ac.za) or post it back to Ms Natasha Danster-Christians, Medical Research Council, Nutritional Intervention Research Unit, PO Box 19070, Tygerberg, 7505 in the prepaid envelope by......... 2011.

The research project has received ethics approval from the MRC Ethics Committee and the contact details have been provided below.

Your participation will be immensely appreciated. I look forward to your positive response.

Any further questions?
You may contact Natasha Danster at Tell: 021 938 0405, Fax: 021 938 0321, E-mail: natasha.danster@mrc.ac.za

Thank you.

Contact details of the MRC Ethics Committee:
Prof Danie du Toit, 021 938 0341; Email: adri.labuschagne@mrc.ac.za

Addendum 6: Ethical approval obtained from The Health Research Ethics Committee of the Faculty of Health Sciences, Stellenbosch University

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23 November 2010

MAILED

Ms N Danster-Christians
Nutritional Interventional Research Unit of the MRC

PO Box 19070
Tygerberg
7505

Dear Ms Danster-Christians

Evaluation of the micronutrient content of South African fortified maize meal and wheat flour sold at retail level.

ETHICS REFERENCE NO: N10/11/374

RE : MODIFICATIONS

A review panel considered the application for interim approval and registration of the abovementioned project on behalf of the Health Research Ethics Committee.

In principle the panel is in agreement with the project, but requested that you should attend to the following matter(s) before the project could be approved:

1. This project should be broken into two studies. The linking of the two data sets is problematic as this will lead to biased data.

On receipt of the additional information/corrected document(s) the application will be reconsidered.

Please provide a letter of response to all the points raised IN ADDITION to HIGHLIGHTING or using the TRACK CHANGES function to indicate ALL the corrections/amendments of ALL DOCUMNENTS, clearly in order to allow rapid scrutiny and appraisal.

Please note that the application for the approval and registration of this project would be cancelled automatically if no feedback is received from you within 6 (six) months of the date of this letter.

Please quote the abovementioned project number in ALL correspondence henceforth.

For standard HREC forms and documents please visit: www.sun.ac.za/rds

Fakulteit Gesondheidswetenskappe · Faculty of Health Sciences

Verbind tot Optimale Gesondheid · Committed to Optimal Health
Afdeling Navorsingsontwikkeling en -steun · Division of Research Development and Support
Posbus/PO Box 19063 Tygerberg 7505 Suid-Afrika/South Africa
Tel.: +27 21 938 9075 · Faks/Fax. +27 21 931 3352

Addendum 7: Ethical approval obtained from the MRC Ethics Committee

ETHICS COMMITTEE

PO Box 19070, 7505 Tygerberg, South Africa
[illegible] Zijl Drive, [illegible], 7500
Tel: +27 (0)21 938-0687; Fax: +27 (0) 866-854023
E-mail: [illegible]@mrc.ac.za
http://www.mrc.ac.za/ethics/ethics.htm

1 April 2011

Ms N Danster-Christians
Nutritional Intervention Research Unit
MRC Cape Town

Dear Ms Danster-Christians

Protocol ID:	EC11-004
Protocol title:	Evaluation of the micronutrient content of South African fortified maize meal and wheat flour sold at retail level
Meeting date:	28 March 2011

Thank you for your response to the Ethics Committee, dated 15 March 2011. The Committee approved the information sheet. I am pleased to inform you that ethics approval is now granted for the study.

Wishing you well with your research.

Yours sincerely

PROF. D DU TOIT
CHAIRPERSON: MRC ETHICS COMMITTEE

Addendum 8: Maize-based short quantified food frequency questionnaire

Food	Picture Card	Description	Code	Capture	Quantity (g/ml)	Amount usually eaten (HHM / g)	Per day	Days per week	Times per month	Seldom/ Never
Maize meal porridge	Pic Card 1	Stiff *pap*	4278	1	A B C D					
	Pic Card 2	Soft *(Porridge)*	4277	2	A B C D					
	Pic Card 3	Crumbly (Phutu)	4279	3	A B C D					
Sour Porridge	Pic Card 4	Maize with vinegar	P0001	4	A B C D					
		Maize Fermented	P0002	4	A B C D					
Samp / Maize rice	Pic Card 5	Samp, White	3250	5	A B C D					
	Pic Card 6	Maize Rice	3250	6	A B C D					
Samp and Beans	Pic Card 7		3402	7	A B C D					
Samp and Peanuts	Pic Card 7		3402	8	A B C D					
Maize meal, cabbage and spinach	Pic Card 8			9	A B C D					
Maize meal and pumpkin	Pic Card 9			10	A B C D					
Mealies		On Cob	3725	11	1 2 3 4					
		Off Cob - Creamed, sweet corn	3726	12	1S 2S 3S 4S S = Table Spoon					
		Off Cob - Whole Kernel Canned	3942	13	1S 2S 3S 4S S = Table Spoon					
Magou / Motogo	Pic Card 10		4056	14	A B C D					
Alcoholic Beverages **made from maize**	Pic Card 10	Specify beer:	4039	15	A B C D					

Addendum 9: Participant information leaflet and consent form

TITLE OF THE RESEARCH PROJECT: **Maize consumption of South African residents**

REFERENCE NUMBER:

PRINCIPAL INVESTIGATOR: Martani Lombard

ADDRESS: Division of Human Nutrition, Room 3085
Clinical Building, Faculty of Health Sciences
Stellenbosch University, Tygerberg campus

CONTACT NUMBER: 021 933-1408

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Ask the study staff any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Health Research Ethics Committee (HREC) at Stellenbosch University **and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.**

What is this research study all about?

This study will be done across South Africa, in all provinces and 3000 people will be included in the study. The studies aim is to find out the average amount of maize people in South Africa eat per day. This will be conducted with a two page questionnaires.

Why have you been invited to participate?

People from each province have randomly been selected to participate in the market research and you will be expected to honestly answer questions about your maize intake.

What will your responsibilities be?

You will be expected to answer the questions about you maize intake as honest as possible.

Will you benefit from taking part in this research?

You will probably not benefit directly from taking part in the study, but it will help the Human Nutrition Division of Stellenbosch University to know what the amount of maize is people consume in South Africa.

Are there in risks involved in your taking part in this research?

There would be no risk when taking part in this study.

Who will have access to your records?

All information provided by you will be entirely confidential. Note that you will receive a copy of this information and consent form for your own records.

The results may however be used for publication in a scientific journal or for presentation at a scientific congress, without revealing your name.

What will happen in the unlikely event of some form of injury occurring as a direct result of your taking part in this research study?

No injury is expected when you participate in the study.

Will you be paid to take part in this study and are there any costs involved?

You will not be paid to take part in the study and you will not have to pay anything to take part.

Is there anything else that you should know or do?

- **You can contact Martani Lombard at tel 021 933-1408 if you have any further queries or encounter any problems.**
- **You can contact the** Health Research Ethics Committee **at 021-938 9207 if you have any concerns or complaints that have not been adequately addressed by your study doctor.**
- **You will receive a copy of this information and consent form for your own records.**

Declaration by participant

I *(name)* ……………………………… declare that I voluntarily agree to take part in a research study described above* and that:

- I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.

Signed at (*place*) ....…........…………….. on (*date*) …………....……….. 2011.

....

Signature of participant Signature of witness

Declaration by investigator

I *(name)* …………………………………………..……… declare that:

- I explained the information in this document to …………………………………..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter. (*If an interpreter is used then the interpreter must sign the declaration below.*

Signed at (*place*) ....…........…………….. on (*date*) …………....……….. 2011.

....

Signature of investigator Signature of witness

Addendum 10: Portion sizes of maize-based dishes

Consumer Survey: Maize food photographs aids

Photograph ID	Food Item	Portion sizes
Picture card 1	Stiff pap	A: 231 g B: 309 g C: 557 g D: 630 g
Picture card 2	Soft pap	A: 269 g B: 308 g C: 478 g D: 640 g
Picture card 3	Crumbly pap	A: 254 g B: 338 g C: 470 g D: 590 g
Picture card 4	Maize fermented with vinegar	A: 231 g B: 308 g C: 478 g D: 640 g
Picture card 5	Samp	A: 155 g B: 207 g C: 414 g D: 622 g
Picture card 6	Maize rice	A: 155 g B: 207 g C: 414 g D: 622 g
Picture card 7	Samp and beans	A: 444 g B: 592 g C: 744 g D: 896 g
Picture card 8	Maize meal with cabbage and spinach	A: 320 g B: 426 g C: 512 g D: 710 g
Picture card 9	Maize meal and pumpkin	A: 320 g B: 426 g C: 512 g D: 710 g
Picture card 10	Mageu,	A: White coffee mug, 250 mL B: Glass, 250 mL C: Small carton, 500 mL D: Large carton, 1 L

Addendum 11: Ethical approval obtained from The Health Research Ethics Committee of the Faculty of Health Sciences, Stellenbosch University

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Approval Notice
New Application

13-Jun-2013
Lombard, Martani MJ

Ethics Refernce #: N13/03/042
Title: Annual National Maize Consumption and Fumonisins Exposure

Dear Doctor Martani Lombard,

The **New Application** received on **28-Mar-2013**, was reviewed by members of **Health Research Ethics Committee 1** via Expedited review procedures on **11-Jun-2013** and was approved.
Please note the following information about your approved research protocol:

Protocol Approval Period: **11-Jun-2013 -11-Jun-2014**

Please remember to use your **protocol number** (**N13/03/042**) on any documents or correspondence with the HREC concerning your research protocol.

Please note that the HREC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

After Ethical Review:
Please note a template of the progress report is obtainable on www.sun.ac.za/rds and should be submitted to the Committee before the year has expired.
The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit.
Translation of the consent document to the language applicable to the study participants should be submitted.

Federal Wide Assurance Number: 00001372
Institutional Review Board (IRB) Number: IRB0005239

The Health Research Ethics Committee complies with the SA National Health Act No.61 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 Part 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

Provincial and City of Cape Town Approval

Please note that for research at a primary or secondary healthcare facility permission must still be obtained from the relevant authorities (Western Cape Department of Health and/or City Health) to conduct the research as stated in the protocol. Contact persons are Ms Claudette Abrahams at Western Cape Department of Health (healthres@pgwc.gov.za Tel: +27 21 483 9907) and Dr Helene Visser at City Health (Helene.Visser@capetown.gov.za Tel: +27 21 400 3981). Research that will be conducted at any tertiary academic institution requires approval from the relevant hospital manager. Ethics approval is required BEFORE approval can be obtained from these health authorities.

We wish you the best as you conduct your research.
For standard HREC forms and documents please visit: www.sun.ac.za/rds

If you have any questions or need further assistance, please contact the HREC office at 0219389657.

Included Documents:
General Checklist
Investigator declaration
Application Form
Investigator CV
Protocol Synopsis
Research Protocol

Sincerely,

Franklin Weber
HREC Coordinator