CHAPTER 5

SIGNIFICANCE OF THE STUDY, CONCLUSIONS AND RECOMMENDATIONS

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

5.1 Introduction

Micronutrient malnutrition contributes to a vicious cycle of poor health and depressed productivity, trapping families in poverty and eroding economic security in countries worldwide with vitamin A, iodine and iron deficiencies as amongst the world's most serious health risk factors. Vitamin A deficiency may also intensify a number of other health conditions, including anaemia (West, Gernand and Sommer, 2007). These broader health consequences further highlight the need to keep vitamin A deficiency controlled, especially during an economic crises. Ensuring adequate intake of this essential nutrient by vulnerable populations will offer enhanced protection from a range of disabilities and diseases, help children grow and learn, and improve health and productivity for adults.

As part of a food-based approach to alleviate micronutrient malnutrition the South African Directorate of Nutrition initiated a food fortification program (FFP). The Department of Health of South Africa embarked on a mandatory fortification program of the two staple foods, white maize meal and white and brown bread flour, with vitamin A, vitamin B_1 (thiamine), vitamin B_2 (riboflavin), vitamin B_3 (niacin), vitamin B_6

(pyridoxine), vitamin B_9 (folic acid), iron and zinc. The fortification level for vitamin A was established at 187.7 µgRE/100g maize meal to provide 31% of the RDA (Department of Health, 2003). The regulations imply that the final maize meal product shall comply with this level.

The aim of the research described in this thesis was to quantify the content of vitamin A in the fortified white maize meal as purchased from retail shelves, as well as that in the cooked porridge as traditionally prepared and consumed. The relative absorption of the vitamin A fortificant commercially used in white maize meal was also determined.

5.2 Significance of the study

5.2.1 Vitamin A content of fortified maize meal and porridge as purchased and consumed in South Africa

In the first study (Chapter 3) it was found that only one brand of white fortified maize meal from a sample of nine different brands complied with the regulatory requirement of 187.7 REµg/100g maize meal. This relates to a compliancy rate of only 11%. These results correlate well with the compliance rate of <20% recently reported by a study funded by the Global Alliance for Improved Nutrition (GAIN) (Umunna and Sunley, 2010). One brand of maize meal (11%) was fortified at a higher level than the mandatory level and seven brands (77%) reported lower values. The highest concentration found in this study was 261 µgRE/100g maize meal and the lowest mean vitamin A concentration was <19 µgRE/100g. The reasons for non-compliance may include:

- Millers do not fortify the maize meal according to standards. This may be a combination of many factors such as lack of competent personnel, lack of available funds to purchase the necessary equipment or analysis of vitamin A in final product on a regular basis;
- Poor uptake of the grant made available by the Department of Trade and Industry of South Africa for fortification equipment by small millers (de Hoop, 2010);
- Low quality fortification mixes supplied by unregistered fortification mix suppliers (DSM, 2009);
- Stability of vitamin A used in the fortification mixes (Mehansho *et al.*, 2003; WHO, 2009); and
- Storage conditions in supermarkets and small shops.

Vitamin A content was determined for each of the maize meal samples and the corresponding porridge samples. An average retention of 39.8% was found. Retention studies done to date conclude that a primary factor in vitamin A loss can be the moisture content in the premix and the maize meal, but that the different qualities of vitamin A compounds may also underlie wide variability in the vitamin A content (Klemm *et al.*, 2010).

To understand the contribution of the fortified maize meal to the vitamin A intake of children, the results were translated into Recommended Dietary Allowance (RDA) values. On average, approximately only 17% of the RDA for children 1-3 years and 13% of the RDA for children 4-9 years old were met by the fortification of the maize meal. This is on average 50% less than what the fortification program intended to contribute to the daily intake of children and it could be even lower depending on the portion size used in the calculation. In this study a portion size of 455 g/person/day for maize porridge was used (Steyn, Maunder and Labadarios, 2006). In a study reported by Schönfeldt, Gibson and Vermeulen (2010) it was found that smaller portions (between 381g and 349g) are consumed, possibly as a coping strategy to counteract increased food prices.

5.2.3 Effect of different maize meal diets on the growth and vitamin A status of chickens

In the second study (Chapter 4) the use and suitability of a biological model were measured. Of importance when choosing an animal model is to always keep in mind the nutrient under investigation. In this study it was vitamin A. The following results were found:

- There is a significant difference in the vitamin A status of chickens consuming a low vitamin A diet vs. an adequate vitamin A diet;
- The chickens performed optimally in growth and showed good vitamin A status in the liver without detrimental effects, when the vitamin A level of the daily intake was set at the optimal level;
- Vitamin A in fortified white maize meal can maintain the vitamin A status of chickens;
- Optimal vitamin A intake is important to obtain a good vitamin A status.

The fortified maize meal diets were able to maintain the vitamin A status of the chickens. Poor absorbability or bioavailability of the fortified vitamin A is therefore not a constraint in combating vitamin A deficiency. It is therefore important to focus on the level of fortification delivered when the fortified food is consumed as a traditional prepared dish. In the traditional diet maize meal porridge is often consumed with a relish of dark green leafy vegetables, which contain phytates and oxalates which may have a negative influence of vitamin A absorption.

5.3 Concluding Remarks

In response to rising food prices, the poor (who are also most vulnerable to VAD) generally tend to purchase and consume smaller amounts of nutrient-dense foods, such as dairy, meat, eggs, fish, fruit and vegetables, while maintaining staple grain consumption despite the higher or fluctuating costs of the grain (Klotz, et al. 2008).

The results of this study indicate that fortification of commonly eaten staple foods with vitamin A could significantly improve the vitamin A intake of children under nine years of age and improve the overall micronutrient density of their diets. This is confirmed by the secondary data analysis of the national dietary data done by Steyn, Nel and Labadarios (2008). However, after five years of mandatory fortification, vitamin A deficiency (VAD) in South African children aged 1-9 years has worsened (NFSC-FB-I, 2008).

The 2005 National Food Consumption Survey- Fortification Baseline found that nearly two-thirds (64%) of children aged 1 – 9 years had a marginal or inadequate vitamin A status, and about one in seven children (14%) were severely vitamin A deficient. KwaZulu-Natal reported the highest proportion (89%) of children with an inadequate vitamin A status, with nearly half of the 1 – 9 year population severely deficient. Similarly, large proportions of children in the Limpopo (76%), Gauteng (65%) and Eastern Cape (64%) provinces had inadequate vitamin A status (NFSC-FB-I, 2008).

A marked increase in the prevalence of inadequate vitamin A status in children aged 1 – 5 years was observed. The national rate has nearly doubled between 1994 (33%) and 2005 (65%). Children aged 3 – 5 years are most affected. The National Food

Consumption Survey reports that, according to internationally accepted criteria, these high rates indicate that vitamin A deficiency is a serious public health problem in South Africa (NFSC, 2000; NFSC-FB-I, 2008).

Vitamin A status of the children was classified according to the World Health Organisation's criteria. Status was determined on the basis of the serum vitamin A concentration present in the blood drawn from children in the sample. Low serum vitamin A distributions (< 0.70 µmol/L) can be assumed to reflect chronic dietary inadequacy of vitamin A from preformed vitamin A and proactive carotenoid sources. However, status data do not provide information about the size of the dietary deficit, or gap, in requirements to meet via fortification or other dietary strategies.

One estimate of dietary gap is the added amount of vitamin A (in micrograms of retinol activity equivalents [µg RAE]) required to shift the intake distribution to the right of the estimated average requirement (EAR) so that only approximately 3% remain below that level in an age group. A second approach is to estimate the amount of vitamin A required to bring the mean of the population to the level of the recommended dietary allowance (RDA) (Klemm et al., 2010). The success of fortification of the second approach can be seen in the case of folic acid. The nutritional goal in the fortification program for folic acid was set at 50% of RDA as opposed to 31% of RDA for vitamin A. In the National Food Consumption Survey Fortification Baseline Study (NFSC-FB-I) done during 2005 an adequate folate status was reported throughout the country (NFSC-FB-I, 2008).

Either estimate of the dietary gap serves to represent the extent to which fortification should increase vitamin A intake to minimize the risk of deficiency. Both require quantified dietary intake data, preferably collected by repeated 24-hour recalls from a representative sample of a target population, assumptions of normality of usual intake distributions, and an adequate food composition database. Unfortunately, few data of this nature, quality, and specificity exist (Klemm et al., 2010).

5.4 Limitations of the study

The following limitations of the study should be noted:

- Although 62 different fortified maize meal samples from nine different brands were analysed, the maize meal sample size (Chapter 3) was still small. To be more representative the number of samples and the brands covered could be increased. Maize meal from small, medium and large scale millers could be included. Such a study is currently being planned by the Department of Health and GAIN (Umunna and Sunley, 2010). For such a study to be successful, adequate funding, a comprehensive sampling plan together with the correct analytical techniques, are of utmost importance.
- Considering the results presented in Chapter 3 and although manuals on fortification of maize meal exist, it will be useful to include in the above-mentioned planned study a survey at the millers regarding *(i)* brand and product name of the fortification mix used, *(ii)* the general conditions under which the fortification mix is stored at the millers, *(iii)* how are the fortification mix added to the maize meal, *(iv)* how often are feeders calibrated, *(v)* the point during the milling process at which the fortification mix is added, and *(vi)* the type of quality control done on site.
- The use of animals as experimental models to gain insight into questions such as absorption of micronutrients (Chapter 4), is most valuable and informative. The ideal will still be to use human subjects to determine absorption and efficiency in a nutrition intervention trial.

5.5 Recommendations

An intervention to increase the micronutrient status of a population is an investment in human health and well-being. A multi-faceted approach is proposed throughout this thesis, including fortification, supplementation and dietary diversification as a sustainable approach to alleviate VAD in the world.

Fortification of foods with vitamin A is a potentially effective intervention to prevent or control vitamin A deficiency in low-income countries where undernutrition and poverty coexist.

The following points must be considered in the planning and execution of an efficient food fortification program:

- The fortification of a food with vitamin A should be designed to correct estimated dietary inadequacy in one or more vulnerable groups, that is, to fill a dietary gap (Klemm *et al.,* 2010). Actual portion size must be taken into consideration.
- The form of vitamin A and premix to be used in fortification should be the highest grade, appropriate for the intended food vehicle, stable under ambient conditions and for the duration of expected use, and introduced into the food supply in accordance with industry standards.
- Monitoring of compliance by all maize millers must be done on a regular basis by an independent organisation.
- Retailers must be trained on how to store and shelve the fortified product. The correct storage place or method can also be conveyed by means of a warning or instructions in different languages on the packaging. These instructions could then also inform the users at household level.

- Fortified products could be marketed through educational messages to children. Such messages should explain the health benefits when these products are consumed. The fortification logo should be used as a marketing tool to create consumer-demand for the fortified product.

The total diet should always be considered when deciding on fortification levels. According to the NFSC (2000), the five most often consumed foods are maize porridge, brown bread, black tea, sugar and a small amount of full cream milk. It is recommended that nutrient content and bioavailability of maize porridge as consumed traditionally with a relish of dark green leafy vegetables be determined. The fibres, oxalates and phytates in the dark green leafy vegetables may interfere with absorption. If tea is the beverage consumed with the meal, the tannins in the tea can also interfere with micronutrient absorption. From a nutritional point of view there are not many absorption enhancers in the abovementioned diet apart from the small amount of milk consumed.

The availability of micronutrient-dense maize might be a suitable alternative to fortified maize meal. Biofortification of cereal staples could have broad potential for ensuring dietary vitamin A adequacy in vulnerable populations by increasing β-carotene intake from readily absorbable staple grain matrices (Graham and Rosser, 2000). Gradually those being reached by biofortified crops might reduce the need for commercial fortification. Biofortification can reach rural populations effectively, and commercial fortification can reach urban populations effectively. The acceptability of such approaches by the identified populations at risk of Vitamin A deficiency, needs further investigation.

Establishing a sustainable vitamin A adequate diet by selecting appropriate food throughout an individual's life cycle remains a challenge particularly amongst the poor in developing countries. These populations often escape the safety nets of government supplementation and fortification programs. It is strongly recommended that international agencies such as the FAO, WHO, UNICEF and GAIN continue to encourage governments to assist individuals at risk of developing VAD with suitable alternatives. This is not only a part of every person's human right to adequate nutritious food, but should also decrease the burden of disease. This is in line with Goal 1 of the millennium development goals: Eradication of extreme poverty and hunger, (MDG's) (UN, n.d.).

5.6 References

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