FOSRIN

Food Security through Ricebean Research in India and Nepal

Report 6: Health and nutrition impacts of ricebean

Nutritional problems among women of reproductive age in rural populations in hill areas in India and Nepal and how they can be reduced by increased intake of Ricebean.

Peter Andersen[1,3] and Ram Krishna Chandyo[2]

[1]Department of Geography, University of Bergen, Norway.

[2]Centre for International Health, University of Bergen, Norway/ Kathmandu Medical College, Department of Community Medicine, Kathmandu

[3]Corresponding author.

Executive summary

The aim of this report is to assess how ricebean fits into the diets and the existing nutritional deficiencies in marginal rural hill areas in India and Nepal. Previous work has been published on the local diets and food preparation (Andersen *et al.*, 2009) and the nutritional value of ricebean (Andersen, 2007).

Ricebean is a traditional and locally accepted grain pulse which primarily is eaten as a *dal* (soaked, boiled soup/sauce served with rice or other staple foods). A number of other recipes are also found, and ricebean can be used as a substitute for other pulses in common, popular food items.

In terms of nutritional value ricebean is comparable to other low fat grain pulses. The content of protein varies but is in many studies in the low end of grain pulses. However, the bioavailability of protein is high and ricebean is assumed to have one of the best compositions of essential amino acids of any grain pulses.

Compared to other pulses, ricebean has a high content of minerals, especially calcium, magnesium, potassium, iron and manganese and in vitamin K, while it to some extent is lower in zinc and some of the B vitamins. The content of phytate is high (2%). Therefore, proper soaking, sprouting and cooking practices are recommended. Ricebean does have some Trypsin Inhibitor effect which disappears with proper cooking, but no known toxic or allergenic properties. Some of its compounds are anti-oxidants and may have anti-carcinogenic and other beneficial health effects.

A dietary survey was undertaken, involving four field teams each interviewing 200 women in rural sites in India and Nepal. The method was based on 24 hour recalls and locally developed “food models” in order to quantify local food items. The recalls were carried out three times in order to provide a good foundation of data as well as to check for variations in food intake linked to seasonality.

The dietary survey showed that the women in all sites are living from diets highly dominated by staple grains. On average, staple grains provided about 80% of the energy intake of the women. Rice was very dominant as a staple in Assam. Rice was also the most important in the sites in Nepal, but here also wheat, maize and millet were staples, and in Himachal Pradesh, both rice and wheat were taken as staples on a daily basis. In all study sites, pulses were a part of the daily diet. In Himachal Pradesh, 46% of the women were vegetarians, and in all sites animal source foods were dominated by milk products and formed a very small part of the daily diet.

The dietary surveys showed that Protein-Energy Malnutrition (PEM) was less prominent than ‘hidden hunger’ – deficiency of micronutrients. The mean values of intake indicated that the most widespread deficiencies were the vitamins A, B_9, B_{12}, C, D and E and the minerals calcium, iron and potassium. In addition, the intake of fat was low. For other nutrients, the mean values were basically close to or above the recommended daily intake for non-pregnant women. However, there were considerable variations in the distribution of intake of the micronutrients, and notably the distribution of intakes of several B vitamins were skewed downwards so that many women were below the recommendations despite mean values indicating sufficient intakes.

The seasonal variations showed no distinctive patterns, except for vitamin A which in some sites was abundant in the season of for instance sweet potatoes or leafy green vegetables.

In a final analysis, the distributions of intake found in the dietary survey were compared to the theoretical impact of adding 30 grams of ricebean to the daily diet, based on the assumption that this could be a realistic measure of increased consumption. The effect of this could move the distribution curve of protein and lysine for non-pregnant women so that most of the women would be forecasted to a safe level of intake of these nutrients.

For folate, potassium and calcium, the concentration in ricebean is very good compared to other plants based food items, but the deficiencies were too serious to be tackled only by a realistic additional intake of ricebean. Only a fraction of the women in the study could be brought to the levels of sufficient folate, potassium and calcium by eating additional ricebean (or other pulses) alone. Improved supplies of for instance leafy green vegetables and milk products will be needed to cover all needs of these, severely deficient nutrients. The distribution of intake of B vitamins other than folate was skewed downwards, so that many of the women were at risk of inadequate supply, but not as severely as in the case of folate. Although the relative concentration of these B vitamins in ricebean is not as high as folate, additional ricebean was found to have the potential to improve the B vitamin supply substantially, but not enough to bring all above the recommended values.

The distributions of intake of iron and zinc were found to range from marginal to sufficient for non-pregnant women, and additional intake of ricebean was estimated to be able to move a substantial number of women from marginal to sufficient status.

A number of the women were pregnant when interviewed. The intakes recorded, compared to the Recommended Daily Allowances (RDA) for pregnant women were low in protein, lysine and zinc, and very low compared to the folate and iron values. Additional ricebean could provide substantial improvement of protein and zinc supply for pregnant women, but the majority would still be below the RDA, whereas ricebean could bring a majority of pregnant women into a sufficient lysine supply. Regarding folate and iron, the intake was too low at the outset to bring more than a few above the RDA value for pregnant women.

The overall conclusions of the report are:

- ricebean has substantial potential to match expected nutritional problems in the region, and thereby food security
- some nutritional problems are too severe to be met with a realistic amount of increased consumption of ricebean (and other pulses) only
- in the cases of severe deficiencies, increased supply of other nutrient dense food items (vegetables, animal source foods) are pertinent in addition to pulses
- the balance between rice and other staple foods is also of substantial importance to the overall adequacy of the diets and should be taken into consideration in local nutritional strategies

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For more information or further copies of this report, please contact:

Dr Peter Andersen, Department of Geography, Universitat Bergen, Norway

Email: peter.andersen@geog.uib.no

Dr Philip Hollington, CAZS Natural Resources, College of Natural Sciences, Bangor University, Bangor LL57 2UW, Wales, UK.

Email: p.a.hollington@bangor.ac.uk

Website: www.ricebean.org

or

Dr Krishna Joshi, CAZS Natural Resources, South Asia Office, c/o CIMMYT, P.O. Box 5186, Singh Durbar Plaza Marg, Bhadrakali, Kathmandu, Nepal

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Contents

1. Introduction

The overall objective of the FOSRIN project is to improve food security in the target group: marginal farming communities in India and Nepal. This is based on two assumptions, firstly that ricebean is an acceptable food suited for local diets in South Asia, and secondly that ricebean has nutritional qualities that are relevant for the target group in the sense that it meets their existing needs. From the outset, it has been assumed that ricebean primarily would play a role in terms of provision of protein and micronutrients, but prior to the project, there was insufficient knowledge of the overall nutritional value of ricebean as well as which nutritional problems were to be expected in the region.

The nutritional value of ricebean itself was documented in Deliverable D5.2 (Andersen, 2007), which was based on detailed information from scientific literature with some additional laboratory analyses, notably on B vitamins. The report concluded that ricebean is a good source of high quality protein, B-vitamins and some minerals, that it contains no allergenic or toxic compounds, and that the level of anti-nutrients in general is comparable to or less than what is found in similar pulses.

Deliverable D5.1 (Andersen *et al*., 2009) was aimed at documenting the existing local uses and processing of ricebean. It found that ricebean primarily is served as *dal*, the pulse based "sauce" which is served along with rice and other staple grains and vegetable curries. The consumption of *dal* is very widespread throughout South Asia, but ricebean is also used for and suited to a number of other dishes that are commonly consumed locally. It was found that there is a good deal of variation in pre-processing of ricebean when it comes to soaking and sprouting before cooking. In order to reduce the effect of anti-nutrients, it should be strongly recommended to soak and/or sprout ricebean prior to cooking since this makes several nutrients substantially more bio-available, in addition to reducing indigestion and reducing cooking time. This is not a problem linked to ricebean only, but should be recommended for all pulses.

Ricebean does play a cultural role in some local communities and is occasionally served with a ritual purpose. In general it is seen as a 'poor man's food' and in that sense stigmatised, but we have not found any direct social or cultural ban on its consumption. Also more affluent groups may consume it occasionally, and in Nepal it is an essential ingredient in the popular *Quantee* mixed bean sprout soup which is consumed across social and cultural divides.

The position of ricebean differs between the hot-cold classifications (see Gittelsohn *et al.*, 1997) which are widespread in India and Nepal. Ricebean may be seen as cold in one place and hot in another. Since there is no scientific reason for classifying ricebean as either hot or cold, the implications for FOSRIN would be to play down this question whenever possible, and instead stress that the nutritional qualities of ricebean makes it a *good food for anyone in any season*.

The present report is aimed at analysing *how increased supply of ricebean may improve the existing diets among marginal, rural women in India and Nepal.*

This entails addressing the following issues:

- the nutritional value of ricebean (see Deliverable 5.2.)
- the nutritional value compared to other pulses
- the existing patterns of nutritional deficiencies in different sites and how they relate to the food items in the diets
- the potential of increased supply of ricebean to meet the deficiencies

The design of the study was limited to deficiencies of various nutrients, in accordance with the focus on marginal population groups and food security. Other potential health benefits from pulses consumption may be issues that are more common in affluent societies, for instance cardiovascular diseases because of cholesterol lowering effects, diabetes and maybe cancer due to the content of various anti-oxidants (Dilis & Trichopoulou, 2009). Even in low income societies, dietary and metabolic changes are occurring that increasingly will make it important to consider these sorts of health issues although they normally are linked to over-consumption of refined foods in rich countries.

2. Methods and study design

The methods and study design applied in the dietary survey are based on 24-hour recalls, largely following the guidelines of Gibson & Ferguson (1999). While their manual primarily was aimed at assessing the intake of zinc and iron in populations, the software applied, WorldFood2 (WF2), and the food lists connected to it, allow for the estimation of a large number of nutrients, see appendix II. WF2 was developed under a project organised by United Nations University (UNU), named INFOODS, in cooperation with University of California. WF2 is downloadable from http://www.fao.org/infoods/software_worldfood_en.stm .

The data collection was carried out by four teams, one headed by LI-BIRD in Mid-West Nepal (Sirseni, Hardineta, Darbar Devisthan and Simichaur VDC's in Gulmi District), one in Eastern Nepal (Dhankuta and Dolakha Districts) headed by NARC, one in Himachal Pradesh, India (Khundia and Trilokpur villages, Kangra district) under management of the Department of Agronomy, CSK HPKV Palampur, and one team working in Assam, India, led by AAU. This 'distributed' model of data collection was decided in order to get an understanding of regional differences in dietary patterns and how these are affecting nutritional adequacy.

Four sites are, of course far from exhaustive in describing the possible variations in diets across more than a billion people in Nepal and India, but can give an indication of which nutritional problems are or are not to be expected in rice-dominated diets, and how these are affected by differences in consumption of staples, pulses, vegetables and animal source foods. The distances between the sites provided the option to record diets with staple compositions completely dominated by rice (Assam), rice and wheat (HP) and rice, maize, wheat and millet (Nepal).

The principle behind 24-hour recalls (in reality: the-day-before recalls) is that the informant normally will have a rather good memory of the actual food intake in this time period. The interview starts with recalling the first meal in the morning, then carefully recalling whatever small or large meals are taken throughout the whole day. 24-hour recalls are less biased by judgment and loss of detail than, for instance, 30 day diaries which also may *induce* a change in dietary habits since the interviewees may start focusing more on their diets if being studied over longer periods.

Although the 24-hour recall only provides a snapshot, the option of repeating and screening a larger group can provide an overview of variations between households as well as seasonality. In terms of the present study, 200 women were interviewed by each team, and the recall was done three times per informant. Ideally, the data collection should have been synchronized between the teams, in order to assess the effects of seasonality, but this was not possible due to the different options in employing field workers, and distances involved and transportation and field access in the different sites.

It was decided to focus on women of reproductive age (20-40) for the study. The rationale was to narrow down the target group for analytical purposes, but also that this group can be considered as particularly at risk of nutritional disorders, due to their biological needs as well as to potential discriminatory intra-household food allocation, although this is not necessarily the case (see Webb, 2002).

In order to align the methods of data collection, an initial workshop was held in Palampur, Himachal Pradesh, from February 20-23, 2007. The workshop contained an introduction to the principles of 24-hour dietary recalls and the WF2 programme, the development of food models, and two days of pilot testing recalls in two villages. The workshop was attended by team leaders, but not by the staff who later became the field data collectors, creating some risk of loss of information between the layers of informant.

2.1 Developing food models

Since the dietary recall method does not imply direct measurements, the method is dependent on a good tool for assessing the quantities taken of different foods. This is done locally, in order to get a good understanding of the local recipes and measures. For this purpose, the first step was development of *food models* for each field area. This implied that the field workers interacted with the local women, establishing the amount of ingredients that went into a bowl of rice, a pot of *dhal*, a potato/cauliflower curry, the local size of a *chapatti/roti* etc., and developed a joint understanding of what would be a very small, small, medium, large or very large serving. As far as possible, the amounts were quantified with electronic scales, backtracking the equivalence of handfuls (which is a quite reliable measure widely used by the women in their daily cooking), bowls, cups, small or large potatoes etc. An important issue in this connection is to make sure that field workers are consistently using dry weight for those food items that are dry before cooking. Food models can never be more than approximate but do provide an opportunity to make an effective screening of sizeable population groups.

2.2. Problems related to the WF2 food tables

The nutrient content in each food ingredient was taken from existing food tables, in this case it entailed using the Indian food table included with WF2. The table contains 123 categories of foods, beginning with: "*apple" – "apple, sugar" – "banana, ripe" – "bean cake, fried" – "bean, cluster" – "bean, field" – "bean, French" – "bean, horse" – "bean, kidney" – "bean, mung" – "bean, mung, mashed or flour"* – etc., the full table is found in Appendix I. For each category, a set of standard values for 48 nutrient parameters are contained in the table, including energy, macro and micronutrients as well as amino acid composition (see Appendix II for the full list).

Since any food item in reality will contain a broad band of nutrients, depending on variety, ecological conditions, storage and processing, the table values are a potential source of error. The categories may be representative or not for food items recorded in a local study, and may even cover several different species as in the case of *"sweet potatoes"* or "*bean cake, fried"*.

In particular, there is no specific category for ricebean in the Indian food table, and the records of ricebean were entered as "*bean, field"* for the calculations of food item contribution to diets. This will tend to overestimate nutrients which are found in higher concentrations in field bean *(Vicia faba)* than in ricebean and vice versa. According to the values found in the Sugiyama Food Composition Database (Anon, 2004; see Table 1), this will mainly lead to some overestimation of protein, phosphorus, zinc and B vitamins while the intake of potassium, calcium, magnesium and iron will tend to be underestimated. Field bean is not significantly different from other pulses, including *Vigna spp,* in its nutrient content. The Sugiyama database does not present data on amino acids.

In principle, it should be possible to edit the food tables and add new items, but the IT staff at the Teaching Hospital, Tribhuvan University, state that is has not been possible in practice. At the present level of ricebean consumption, this has had limited impact on the overall picture.

A bigger problem arises from the nutrient values for other pulses. The source of the nutritive values in the table is, according to the WF2 user's guide, Gopalan *et al.,* 1989, which has not been accessible to the authors. The nutritional values for pulses in the table appear to be low compared to what would otherwise be expected, and it appears most likely that these values are based on cooked – wet weight – while staples such as rice are represented in the WF2 food tables with nutrient values that obviously are based on dry weight. The instruction to field workers was to develop estimates of the dry weight. Thereby, the total contribution of pulses to diets as they have been found in the dietary recalls should be read with caution, and it is assumed that the contribution of pulses in reality is higher with respect to all nutrients.

A separate set of nutritional values was elaborated for Andersen (2007), based on scientific literature and laboratory analyses, and these were used for the analysis of potential impact of ricebean for nutritional improvement. This dataset corresponds generally well to values found in the Japanese Sugiyama Food Composition Database (Anonymous, 2004), which however does not contain amino acids, and which therefore has not been used for the WF2 analysis. The nutrient values in this database, which was developed by the Laboratory of Food Function, Department of Food and Nutrition, School of Life Studies, Sugiyama Jogakuen University, originate from the Standard Tables of Food Composition in Japan, Fifth Revised Edition - 2000.

2.3 Effects of substitution – nutritional value of ricebean compared to other pulses

Since ricebean may not only add to total pulse consumption, but may serve as a substitute, the nutritional value of ricebean compared to other pulses is of interest. The impact of substituting other pulses with ricebean depends on their relative nutrient content. Due to the above mentioned problems with the WF2 database, the following is based on the Sugiyama Database (*loc cit*). The database contains rather detailed information on ricebean as well as a number of other pulses and enables a comparison between the nutrient content of ricebean and some other pulses.

Table1. Ricebean compared to eight other pulses, based on the Sugiyama Food Composition Database (Anonymous, 2004)

Food and description	Soybeans	Mung beans	Lima beans	Broad beans	Azduki beans	Kidney beans	Lentils	Scarlet runner beans	Av. of eight pulses	Rice beans	Significant difference
Energy, kJ	1745	1481	1460	1456	1418	1393	1477	1389	1477	1448	
Energy. kcal	417	354	349	348	339	333	353	332	353	346	
Water. g	12.5	10.8	11.9	13.3	15.5	16.5	11.4	15.4	13.4	12.3	
Protein. g	35.3	25.1	22.9	26	20.3	19.9	23.2	17.2	23.7	20.3	
Lipid. g	19	1.5	1.8	2	2.2	2.2	1.3	1.7	4.0	1.6	Lower
Carbohydrate. g	28.2	59.1	59.6	55.9	58.7	57.8	61.3	61.2	55.2	61.8	
Ash. g	5	3.5	3.8	2.8	3.3	3.6	2.8	4.5	3.7	4	
Sodium. mg	1	0	Tr	1	1	1	Tr	1	0.8	1	
Potassium. mg	1900	1300	1900	1100	1500	1500	1000	1700	1488	1400	
Calcium. mg	240	100	75	100	75	130	58	78	107	290	Higher

Food and description	Soybeans	Mung beans	Lima beans	Broad beans	Azduki beans	Kidney beans	Lentils	Scarlet runner beans	Av. of eight pulses	Rice beans	Significant difference
Magnesium. mg	220	150	170	120	120	150	100	190	153	230	Higher
Phosphorus. mg	580	320	200	440	350	400	440	430	395	340	
Iron. mg	9.4	5.9	6.1	5.7	5.4	6	9.4	5.4	6.7	12.5	Higher
Zinc. mg	3.2	4	5.5	4.6	2.3	2.5	5.1	3.4	3.8	3	Lower
Copper. mg	0.98	0.91	0.75	1.2	0.67	0.75	0.96	0.74	0.87	0.74	
Manganese. mg	1.9	0	0	0	0	0.54	1.69	1.5	0.70	2.7	Higher
Retinol. ug	0	0	0	0	0	0	0	0	0	0	
Carotene. ug	6	150	0	5	7	12	28	4	27	22	
Retinol equivalents. ug	1	25	0	1	1	2	5	1	5	4	
Vitamin D. ug	0	0	0	0	0	0	0	0	0	0	
Vitamin E. mg	3.6	0.9	0.5	1.2	0.6	0.3	1.4	0.4	1.1	0.7	Lower
Vitamin K. ug	18	16	6	13	8	8	14	8	11	28	Higher
Vitamin B1. mg	0.83	0.7	0.48	0.5	0.45	0.5	0.55	0.67	0.59	0.46	Lower
Vitamin B2. mg	0.3	0.22	0.18	0.2	0.16	0.2	0.17	0.15	0.20	0.14	Lower
Niacin. mg	2.2	2.1	1.9	2.5	2.2	2	2.5	2.5	2.2	1.7	Lower
Vitamin B6. mg	0.53	0.52	0.41	0.41	0.39	0.36	0.54	0.51	0.46	0.25	Lower
Vitamin B12. ug	0	0	0	0	0	0	0	0	0	0	
Folate. ug	230	460	130	260	130	85	59	140	187	180	
Pantothenic acid. mg	1.52	1.66	1.26	0.48	1	0.63	1.77	0.81	1.14	0.35	Lower
Ascorbic acid. mg	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	
Saturated fatty acids. g	2.57	0.34	0.4	0.24	0.27	0.25	0.16	0.21	0.56	0.32	Lower
Monounsaturated fatty acids. g	3.61	0.04	0.1	0.33	0.07	0.18	0.27	0.1	0.59	0.1	Lower
Polyunsaturated fatty acids. g	10.49	0.61	0.73	0.65	0.55	0.79	0.42	0.85	1.89	0.55	Lower
Cholesterol. mg	Tr	0	0	0	0	0	0	0	0	0	
Water soluble dietary fibres. g	1.8	0.6	1.4	1.3	1.2	3.3	1.1	1.2	1.5	1	
Water insoluble dietary fibres. g	15.3	14	16.5	8	16.6	16	16	25.5	16.0	20.7	
Total dietary fiebers. g	17.1	14.6	17.9	9.3	17.8	19.3	17.1	26.7	17.5	21.7	

Table 1 compares ricebean with soybean (*Glycine max*), mungbean (*Vigna radiata*), lima bean (*Phaseolus lunatus*), broad bean (*Vicia faba*), adzuki bean (*Vigna angularis*), kidney bean (*P. vulgaris*), lentil (*Lens culinaris)* and scarlet runner bean (*P. coccineus*). Within this group, soybean is rather different to the others due to its high fat and protein content. Ricebean is close to the average values for the eight other pulses in the analysis, but substantially lower than the average in fat, vitamin E, B1, B2, niacin, B6 and pantothenic acid. On the other hand, it contains considerably higher amounts of calcium (290 mg / 100 g compared to an average of 107 mg for the eight other pulses), iron (12.5 mg against 6.7 mg), manganese (2.7 mg against 0.7 mg) and vitamin K (28 µg against 11 µg).

The Japanese food database does not include amino acids, but several of the studies referred to in Andersen (2007) concluded that ricebean is particularly advantageous for human consumption in terms of amino acid composition.

Food tables cover over a large internal variation of nutrient content in the different foods, and some of the values in the Sugiyama tables differ from the nutrient values on ricebean published in Deliverable 5.2. Therefore, the results can only been seen as indicative.

A general conclusion on the basis of previous results (Andersen, 2007) and the Sugiyama database is that substituting other pulses with ricebean will increase the intake of minerals, especially calcium, iron, manganese and vitamin K, and a better amino acid balance, but it may reduce the intake of some B vitamins. When compared to the forecast nutritional problems in the study areas, the positive impact on calcium, potassium and iron intake appears to be the most beneficial.

3. Results

3.1 Evaluation of adequacy of intake based on mean values of intake

The results from the dietary recalls and the nutrient content of ricebean have been compared to the intakes recommended by Food and Nutrition Board, Institute of Medicine, National Academy of Sciences, USA (NAS, 2004). For amino acids, the values used are from NAS 2005. There are different categories:

RDA – Recommended Dietary Allowance –set to “meet the needs of almost all (97-98%) individuals in a group”.

EAR – Estimated Average Requirements are minimum intakes which will meet the need of 50% of people in a specific age and gender group

AI – Adequate Intakes – assumed to meet the requirements of all individuals, but uncertainty about the needs does not permit to specify the percentage covered precisely.

Some special nutrient requirements are also listed for women who are pregnant or lactating. This is particularly important in the case of iron and vitamins (especially folate). In addition, NAS (2004) includes a list of tolerable upper intake levels (UL) of a number of elements.

The basis of the recommendations is data from American population and since most data are not adjusted for bodyweight and metabolism, it may be discussed whether there is a complete transfer value to the body size and physical activity of women in rural South Asia. However, the figures should give an indication of the problems to be forecasted. The compiled intake for the different values can be interpreted as follows:

3.1.1 Energy

The requirement for energy differs substantially depending on height, body mass and physical activity. The recorded mean consumption from West Nepal were from 2018-2174 kcal, East Nepal 1712-1990 kcal, HP 1192-1322 kcal and Assam (two subsets of data) 2161-2272 kcal. The data from HP are clearly a systematic error in the estimation of staple foods; however, but since the data set otherwise appears consistent, it was decided not to discard the data set from the further analysis. A good proxy of the adequacy of energy supply is the weight and BMI (body mass index) recorded in the baseline study (Table2).

Table 2. Weight and BMI from baseline study

	West Nepal	East Nepal	HP	Assam
Mean weight (SD)	48.3 (7.1)	49.1 (7.2)	49.2 (9.1)	47.7 (4.7)
Mean BMI (SD)	21.4 (3.0)	21.7 (2.7)	21.2 (3.9)	21.0 (1.9)
BMI < 18.5	13.5%	11.5%	25.5%	10.5%

This indicates a meagre diet but still only a minority of the women was in the category “underweight”. The higher figure for underweight women in HP is probably caused by food sources (almost half being purely vegetarian) more than the odd values for staple consumption. The lowest BMI value was 13.7 and was found in HP.

However, one factor affecting the frequency of underweight as expressed by BMI was the height of the women, with a mean ranging from 150-152 cm between the sites since the HP women were taller. The average woman would fall into the category 'stunted' (below 2 standard deviations of the expected mean) compared to the NAS standards. In an Indian context, it can be compared to the overall median of 151.8 cm (Viswanathan & Sharma, 2009) and the height recorded can be seen as typical of poor, rural women.

The sources of energy show the overall dominance of rice in the diets. On average, rice was estimated to contribute 63.6% of the total energy, wheat 8.3%, maize 6%, potatoes 2.7%, milk 2.6%, pulses 2.3%, vegetable oil 2.0% and sugar 1.3%. The figure for pulses is probably underestimated, as discussed above.

3.1.2 Protein

The mean consumption of protein was sufficient compared to the EAR value of 38 g per day. Applying the RDA value of 46 g, it was found marginal in East Nepal (43-49g) and HP (40-44 g) but otherwise sufficient. Permitting for the underestimation of staples in HP, it may in reality be relatively sufficient. However, for pregnant women, (EAR = 50 g, RDA = 71 g) protein supply tended to be below recommended values at all sites. The predominant sources of protein were rice, providing 45%, wheat 12%, meat, fish and poultry 11%, pulses 7%, milk and buttermilk 6% and maize 5%. Due to the above mentioned problems with the table values for pulses, their contribution to protein as well as other nutrients is likely to be underestimated.

3.1.3 Amino acids

Interestingly, the mean intake of all amino acids (Table 3) appeared to be considerably above the recommended values at all sites, except for a slightly low supply of lysine in one recall in HP, which may be explained by the odd values for staples. Otherwise, the recorded mean intake of each essential amino acid was typically twice the requirements. The explanation is, assumedly, that the existing complementary contributions of staples, pulses, dairy produce and vegetables is a good adaptation to food resources in the region even at a low or absent intake of meat.

The main source of all amino acids was, due to its predominance in the diet, rice. One striking issue in Table 3 is the relative importance of wheat in providing amino acids. A shift in the staple grain composition from rice to wheat can have substantial positive impact on the amino acid supply.

Table 3. Sources of different amino acids in the dietary surveys

	% from rice	% from wheat	% from pulses
Tryptophane	42.7	15.7	5.8
Threonine	43.4	9.7	7.1
Isoleucine	44.4	10.6	6.7
Leucine	44.9	10.1	6.1
Lysine	33.8	7.1	8.7
Methionine	48.8	8.9	3.6
Cystine	53.0	16.5	4.7
Phenylanaline	48.6	11.9	6.5
Tyrosine	43.9	10.6	5.2
Valine	48.5	9.9	5.8
Arginine	54.3	8.5	8.0
Histidine	41.4	11.3	7.4

The most critical amino acid in the survey was lysine, which is relatively low concentration not only in rice but also other staple grains. Therefore, the relative contribution of lysine from pulses was also the highest.

3.1.4 Fat

The mean calculated intake of fat varied from 15-28 g per day. The recommendation concerning fat from NAS is that it should constitute from 20-35% of the energy for adults. Assuming energy content of 9 kcal per g fat, the recorded amounts would provide from 135-232 kcal or about 7-12% of total energy consumption. This may constitute a problem concerning the uptake of fat soluble nutrients. In addition, several vegetable oil types are good sources of vitamin E. The main source of fat is cooking oil which predominantly is a purchased item, so price can be a limiting factor. Vegetable oil provided 24% of the supply, milk 19%, rice 11%, maize 6%, mustard 5%, pork 5% and wheat 5%. The fact that the little fat in staple grains show up as important sources of fat, is another evidence of their dominance in the diets. The composition was 36% saturated, 19% monosaturated and 45% polysaturated fatty acids. Milk was the major source of saturated fats.

3.1.5 Fibre

The recorded values for fibre were close to the recommendations (25 g per day) in West Nepal (31-34 g) and HP (31-32), but low in East Nepal (16-22) and Assam (15-19). The main explanation for this is that rice is a poor source of fibres so that a larger proportion of wheat and maize leads to more fibres in the diet.

3.1.6 Phytate

Although phytate also plays a role as a nutrient and source of phosphorous, the main concern is that it also acts as an anti-nutrient, especially by reducing the bioavailability of iron and zinc (Harland & Oberleas, 1987). Therefore there is no recommended value for phytate. The recorded mean intake of 1868-2413 mg indicates that the predominantly plant based diet provides a very high intake of phytate compared to western diets. Although pulses are particularly rich in phytate, the staple grains were still the main source of phytate due to their dominance in the diets. Rice alone accounted for 54% of the total phytate, wheat 18% and maize 12%

3.1.7 Vitamin A

The values for vitamin A showed a general deficit in all sites except for Assam, but there were also recalls in east Nepal and HP with mean sufficient supply. The RDA is 700 µg retinol equivalents per day for non-pregnant women, and as much as 1300 µg per day for lactating women. The range of mean values calculated were 324-403 µg in West Nepal, in West Nepal, 215-1045 µg in East Nepal, 178 – 602 µg in HP and 804-1094 µg in Assam. This nutrient has the highest seasonal variability, and when scrutinized, it appears that it is linked to variations in availability of sweet potatoes, green leafy vegetables and mangoes, and thereby reflecting a ‘real’ seasonality in supply. The general picture is one of widespread and severe deficiency. The main sources were the WF2 categories leafy green vegetables (43%), hibiscus leaves (9%), pumpkin leaves (8%) and spinach (7%). It may be that a rather large number of species have been assigned to these categories, and that these may differ substantially with respect to real vitamin A content, therefore these figures should be read with a good deal of caution.

3.1.8 Vitamin B1 - thiamine

The supply of the vitamin B complex is particularly interesting in connection with pulses since many of these, and also ricebean, can be important sources of B vitamins which is their main role in vitamin supply (Dilid & Trichopolou 2009). The mean intake of thiamine was varying between 0.8 and 1.2 mg per day. Compared to the RDA of 0.9, the intake in all recalls in West Nepal and one in Assam were low, whereas the mean of the other recalls were sufficient. For pregnant women, the RDA is set at 1.2 mg per day, which was the mean of one recall in West Nepal, the rest were below. Generally, the picture is that the supply is marginally sufficient. However, the mean values do cover a considerable variation in distribution which is discussed in section 3.3. The main sources of thiamine were rice (23%), wheat (19%), maize (14%) and potatoes (7%). Pulses provided 8%, but as discussed in the paragraph on food tables, this figure is likely to be underestimated, and so the total supply.

3.1.9 Vitamin B2 - riboflavin

Consumption of riboflavin was calculated to between 0.6 and 1.0 mg per day, compared to a RDA of 0.9 mg per day. All sites except for West Nepal were having means below the RDA. For pregnancy, an RDA of 1.2 mg per day is prescribed, in which case all sites fall in a risk of deficiency range. The main sources were rice (28%), milk and buttermilk (19%), wheat (12%), maize (9%). The total contribution of pulses was calculated to 5.5%.

3.1.10 Vitamin B3 – niacin

The intake of niacin was calculated at 9.0 and 13.4 mg, compared to a RDA of 14, but18 for pregnant women. Thereby the mean at all sites were in a low range compared to the RDA. Rice was the main source of niacin, providing 33%, wheat accounted for 23%, maize 11% and potatoes 7%. The total contribution from pulses was 4%.

3.1.11 Vitamin B5 - pantotenic acid

Recommended values for pantotenic acid are given as AI (Adequate Intake), 5 mg per day for non-pregnant and 6 for pregnant women. The consumption in the study found that women in HP were getting 3.6-3.9 mg while at the other sites it ranged from 5.3-7.6 mg per day. The explanation for the low values in HP may well be the odd measurements for rice, since rice in the overall study contributed 65% of the pantotenic acid, followed by 7% from wheat and 5% from potatoes. Thereby, it is likely that the general supply is adequate.

3.1.12 Vitamin B6 - pyridoxine

The mean values for vitamin B6 were between 1.2 mg per day (HP) and 1.7 (Assam). Compared to a RDA of 1.3, only HP was low, but if the requirements for pregnant women of 1.9 mg per day should be met, all sites were in a low range. Rice provided 35%, potatoes 12%, wheat 11% and maize 7%. Pulses in total provided 4%.

3.1.13 Vitamin B9 – folate

The dietary recalls found values from 154 (West Nepal) to 303 (Assam) µg per day, meaning that all sites were substantially below the RDA of 400 µg for non-pregnant and 600 µg for pregnant women. Folate is not least important during the first phase of pregnancy in order to prevent neural tube defects. In this case, pulses were the major source (26%), followed by leafy green vegetables (20%), rice (9%) and wheat (6%). Again, the figure for pulses is likely to be underestimated, and folate is one of the most important issues in terms of undernutrition as well as the importance of pulses in the diet. Ricebean, with a content of about 130 µg (Sugiyama database 180 µg) per 100 g, can play a considerable role in provision of sufficient folate, but should be accompanied by other good sources such as leafy green vegetables.

3.1.14 Vitamin B12 – cobalamine

Not unexpectedly, vitamin B12 was found to be another major deficiency, with mean intakes from 0.5 µg per day in three recalls in East Nepal, HP and Assam respectively, up to 1.2 µg per day in one recall in West Nepal. The RDA is 2.4 for non-pregnant and 2.6 µg per day for pregnant women. The main sources were milk (29%), fish (26%), meat (19%) and buttermilk (17%). Since B12 is only found in animal source foods, pulses are not of importance in this connection apart from the indirect value of plant residue as livestock fodder.

3.1.15 Vitamin C

The mean vitamin C supply ranged from 27 (West Nepal) to 78 mg per day (one recall in Assam) and was basically below EAR (60) and RDA (75). The cause is insufficient consumption of vegetables and fruit. The main sources are leafy green vegetables (26%) and potatoes (20%) which are important ingredients in vegetable curries. Pulses, including ricebean, are not a good source of vitamin C.

3.1.16 Vitamin D

Vitamin D was found to be supplied in only minute quantities through food, from about 0 to 0.26 µg per day in Nepal and HP. The recommended values are 12 µg (EAR) and 15 (RDA) for adult women. In Assam, the supply was higher (1.8-2.6 µg) due to consumption of fish and pork which are the main sources (86 and 8% respectively). The severity of the problem is, however, dependent on exposure to sunlight. Despite the climate, exposure to sunlight may be substantially constrained by cultural codes, and it can not be ruled out that for instance the use of veil in HP can contribute to vitamin D deficiency. However, the food chain does not provide sufficient of vitamin D, and it is a potential health risk, aggravated by the deficiencies in calcium supply.

3.1.17 Vitamin E

The supply of vitamin E was ranging from 1.4-4.3 mg per day of tocopherol equivalents. This is far below the recommended values (EAR = 12, RDA = 15 mg/d) for adult women. The main sources of vitamin E in the diets were leafy green vegetables (31%), wheat (20%), maize (13%) and fish (8%). Pulses were not an important source of vitamin E in the study. Polished rice is a very poor source of vitamin E. In the WF2 Indian data base the content is rounded down to zero. The USDA National Nutrient Database for Standard Reference states that the content of the category "*white, long-grain, regular, cooked*" rice is 0.04 mg/100g; a consumption of 400 g of rice would thereby provide 0.16 or about one percent of the DRI.

3.1.18 Calcium

Calcium appears to be a major deficiency. The AI value is given as 1000 mg per day for non-pregnant as well as non-pregnant women. In the recalls, the mean intake was found to be from 299-565 mg. The main source was milk and buttermilk (35%), leafy green vegetables (15%) and rice (8%). The contribution from all pulses was 5%, but again probably an underestimate. In the case of calcium, ricebean is a particularly rich source according to the literature. The Sugiyama Food composition data base states that ricebean has a content of 290 mg / 100 g, the highest of all beans in the data base; in Mohan & Janardhanan (1994), the mean of six ricebean varieties was 264 mg per 100 g.

3.1.19 Phosphorus

The RDA for women's intake of phosphorus is 700 mg/d, pregnant or non-pregnant, and the mean of the recalls ranged from 809-1327 mg. Thereby, there is no reason to expect low intake of this nutrient, which is not surprising considering the high intake of phytate. The main sources are rice (36%), wheat (16%) and maize (8%). Pulses were calculated at 7% of phosphorus intake.

3.1.20 Magnesium

Magnesium RDA is 310-320 mg/d for non-pregnant women and 350-360 mg/d for pregnant. The mean values from the field survey ranged from 286 mg/d in one recall in Assam to 485 in Gulmi. The majority of the recalls had mean intakes of magnesium above the RDA and it is not forecasted as a major nutritional problem. There was a good deal of variation between the recalls within the sites and no area had consistent low values. The major sources of magnesium were rice (36%), wheat (18%), maize (12%), pulses (5%) and potatoes (4%).

3.1.21 Potassium

The recommendations for potassium are AI, 4700 mg/d for non-pregnant as well a pregnant women. All study areas had much lower values than this, from 1494 mg/d in one recall in East Nepal to 2300 in one in Assam. Rice was the major source (17%), followed by potatoes (13%), wheat (11%), pulses 8%, milk (6%) and maize (6%). In other words, rice is a particularly bad source of this mineral, and not sufficiently compensated for by richer foods. Mohan & Janardhanan (1994) found a mean value for ricebean at no less than 2875 mg/100g while the Sugiyama Food composition data base only state 1400 mg/100g. This is another nutrient where substantial deficiencies are forecasted and where ricebean appears to have a major potential.

3.1.22 Sodium

Although the calculated supply of sodium in the food is far below the AI of 1500 mg/d, this relates only to the food items and it is taken for granted that people are adding salt to their food.

3.1.23 Iron

The supply of iron is a complex issue since the table values of requirements differ substantially. While the EAR non-pregnant women in the age group 19-50 years is 8.1 mg/d, the RDA is 18 mg/d, while for pregnant women in the same age group it is 27 mg/d. The mean values encountered in the recalls ranged from 7.2 mg/d in one recall in Assam to 13.8 mg/d. Taking departure in the RDA values, substantial inadequate intake of iron were found among non-pregnant women, and even more in the case of pregnancy.

The major sources of iron in the recall were rice (20%), reflecting a very low concentration compared to the total amount of rice in the diet, wheat (18%), mixed spices (12%), pulses (12%), maize (12%), millet (4%), mustard (3%) and leafy green vegetables (3%). The importance of wheat which only provided 8% of the energy supply is underlining the importance of the balance between different staples in the diet. The very high figure for mixed spices may be a fact since several ingredients in common Asian spices are very rich in iron, but the table category is broad and thereby subject to large uncertainties. Pulses are likely to be underestimated due to the WF2 data list, but do score high anyway.

Ricebean contains 6.7 mg Fe/100g (Mohan & Janardhanan, 1994). This corresponds quite well to total iron values of 6.3-7.7 mg/100g, presented by Kaur & Kapoor (1992). Kaur & Kawatra (2002) found total iron content values between 7.5 and 8.3 mg/100g. The Sugiyama data base states an iron content of 12.5 mg/100g of ricebean, the highest of all beans in the data base and about twice the mean content of other pulses (6.7 mg/100g).

The issue is further complicated by the question of antinutrients. According to the software documentation, WF2 does contain an algorithm which should deduct for the effect of phytic acid on availability of iron and zinc. However, while the pulses in general are higher in both nutrient (iron, zinc) and antinutrient (phytic acid) than staple grains, the ratio between these will again be dependent on the preparation.

To conclude, there seems to be a risk of widespread iron deficiency, especially affecting pregnant women, and pulses, including ricebean, have a substantial potential to alleviate the problem, but due to the complexity of the issue, the figures should be read with caution.

3.1.24 Zinc

The RDA value of zinc for adult women is 8 mg/d, while 11 mg/d is recommended for pregnant women. The values found in the survey varied from 7.2-8.5 in Dolakha, 9.1-10 in Gulmi, 7.7-8.4 in HP and 7.5-8.8 in Assam. Thereby, the mean intake of zinc is about sufficient for non-pregnant but deficient at all sites for pregnant women. The main sources of zinc were rice (44.7%), wheat (15.9%), maize (7.2%), meat (6.5%), pulses (6.1%) and milk products (4.7%). The Sugiyama database notes the zinc content of ricebean to be 3 mg/100g of ricebean, against a mean of 3.8 mg/100g in other pulses. Thereby, substituting other pulses with ricebean may have negative consequences for zinc supply. Zinc is affected in the same manner as iron by phytate and other anti-nutrients.

3.2 Assessing the potential increase in pulse consumption

Table 4. Mean intake of pulses (g day^{-1}) in the four study areas.

	Mean	Min.	Max.	S.D.
Dolakha	31.5	4	120	19
Assam (subset)	25.3	10	50	10.3
Gulmi	44.9	5	300 (?)	33.6
HP	39.6	5	180	23.7

Source: FAOSTAT

One assumption behind FOSRIN is that the present consumption of pulses is constrained by a combination of availability and affordability. Table 4 shows the calculated pulse intake from the dietary survey. The overall mean intake of around 35 g per day is comparable to the national statistics. The statistics from India show that there has been a substantial decline in production and thereby also availability of pulses over the last four decades, from 63 g / cap. / day in 1961 to around 30 g / cap. / day in 2001 (Table 5)

Table 5. Pulse consumption in India 1961-2001, g / capita /day.

Year	1961	1971	1981	1991	2001
Consumption	63	44	33	38	30

Source: FAOSTAT

The potential nutritional impact of enhanced pulse production will depend on an increase in consumption which is not known. There is, of course a maximum limit to the amount of pulses that will be eaten, even if not constrained by availability and affordability. No-one would like to eat many hundreds of grams of pulses in a day, considering the unpleasant effects it might have on the digestive system.

But how much is ‘a full treat’? The first author of this report has measured the amount of lentils and other pulses served in private homes and restaurants in a number of instances in Nepal, and found as a rule of thumb that about 30-35 g of pulses per person and meal appears to be a common measure. With two main meals a day, it would be about 60-70 g.

We will consider that these occasions have been moments of ‘unconstrained hospitality’. However, these observations have not been organised systematically. Another indication may be gathered from Indian statistics (NSSO, 2001).

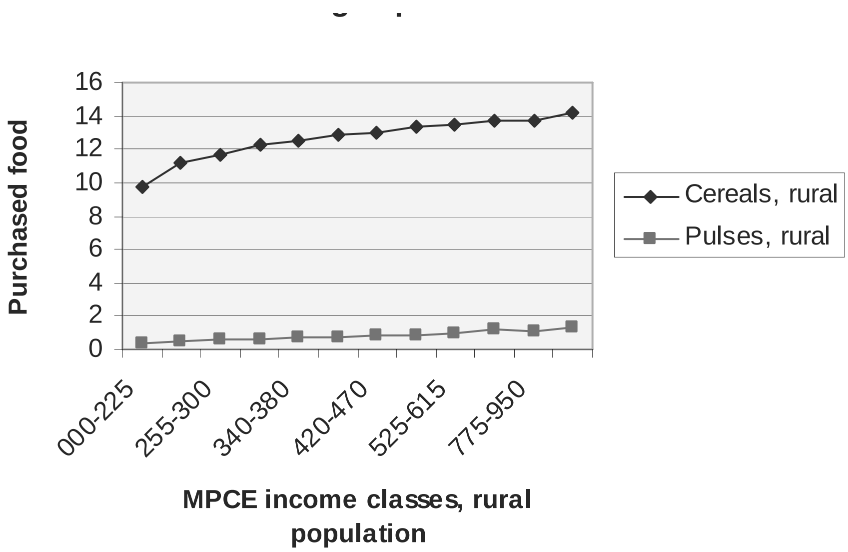

Figure 3.2.1: Income elasticity of cereal and pulse consumption (kg/capita/month)

The data in this report exhibit strong income elasticity when it comes to pulse purchases, confirming the affordability hypothesis. The respondents were divided into urban and rural households and each of these were divided into twelve MPCE (Monthly per capita expenditure) classes according to household incomes. In urban households, the lowest MPCE class was purchasing 0.49 kg of pulses and pulse products per person per 30 days or 16.3 g per day, whereas the highest MPCE class purchased 1.38 kg per 30 days or 46 g per day. In rural areas, the lowest MPCE class purchased 0.38 kg of pulses and pulse products per person per 30 days or 12.6 g per day, while the highest MPCE class purchased about 1.30 kg or 43 g per day. In other words, the difference between low and 'unconstrained' pulse intake was in the order of 30 g per day.

If we assume that the consumption in the highest income group is close to unconstrained by purchase power, we will argue that this indicates the potential increase in consumption by the poorest groups. This does require that other dietary habits remain unchanged. In real life it may be subject to changes in consumption such as increased meat consumption, either due to changes in cultural norms and availability, or to changes in purchase power. In the final section, it will be assumed that 30 g per day represents a realistic, additional intake of pulses in economically marginal populations.

3.3 Predicted impact of enhanced intake of ricebean on distributions of nutrient intake

While the previous section was attempting to identify the existing pattern of nutritional adequacies in the four sites, this final part of the study is aimed at predicting which impact increased consumption of ricebean would have on meeting nutritional requirements compared to what was forecasted in the nutritional surveys.

The input from the survey has been joined in one data table. The most questionable subsets that were encountered have been left out from the calculations. It may still be that some outliers in the lower and higher ranges can be suspected to be errors either in from the survey or from the data processing. A total of 2071 recalls have been applied in the calculations.

The values are presented as histograms, showing that the surveys are representing a relatively broad range of intakes. The use of histograms is also aimed at visualising how the impact of increase consumption of ricebean will basically be a shift in the distribution range. It is also noticeable from the histograms that there are large variations in the pattern of distributions, whether being skewed or close to normal distributions. The Y-axis in the histograms is number of 24 hour recalls.

Cut off values for EAR, RDA, RDA (pregnant) and AI from National Academy of Sciences (2004), were added to the histograms in order to relate intake to bodily requirements. Lack of data restricted the use of confidence intervals for AI to pantotenic acid, calcium and potassium.

The calculations of enhanced pulse consumption are based on adding the contribution of 30 grams of ricebean to the measured intakes. This is a simplification in some respects: it is maybe unlikely that increased availability would lead to an equal increase in intake by all individuals, given the opportunity it is likely that the increase would be higher in the lower end of intake, and that women who already had a relatively high intake would be closer to having their appetite satisfied. In the calculations of the added nutrients from 30 grams of ricebean, the net content has been used, not considering the bioavailability. This means that the predicted additional contributions are likely to be somewhat exaggerated. However, it should be providing an indication of the potentials, but also the limitations, of ricebean to fill gaps in the existing nutritional requirements.

The following nutrients were selected for the ‘impact analysis’:

- protein
- lysine
- B vitamins (except B12)
- potassium
- calcium
- iron
- zinc

The choice of these nutrients was made according to their specific severity in the field survey, and to elucidate different relationships between nutritional needs and how they may be met by ricebean.

3.3.1 Protein

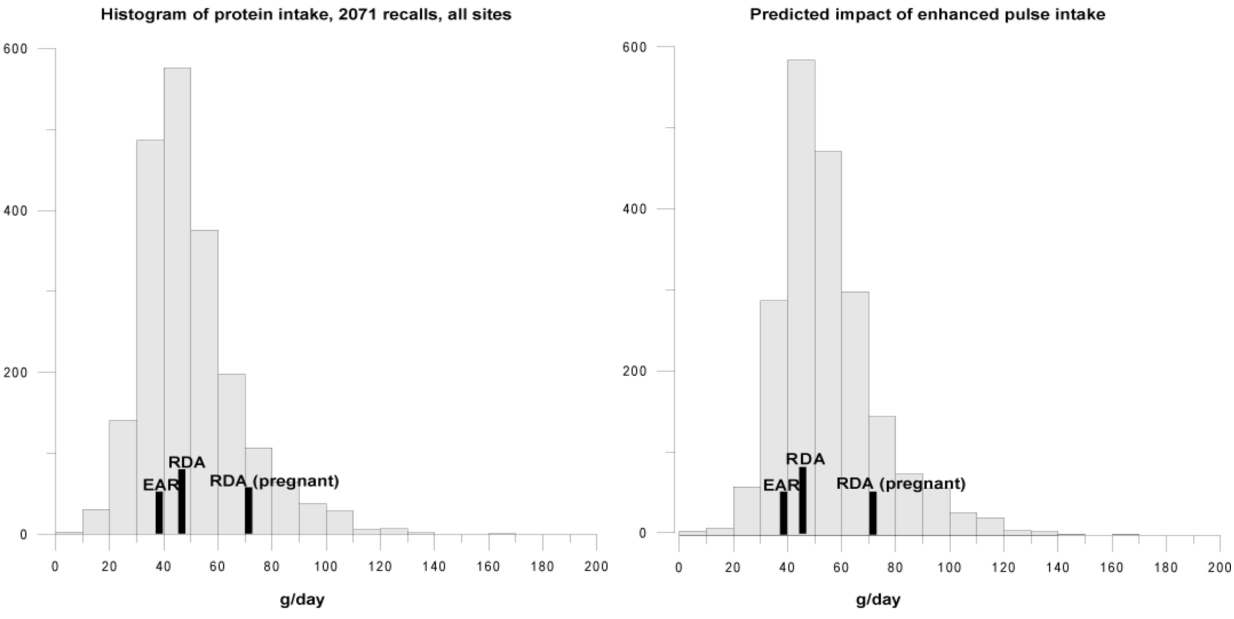

Figure 3.3.1: Actual and predicted protein intake

The provision of protein in the survey was as discussed in the previous section, while not the most urgent problem when comparing *the mean* intake to the recommended values for non-pregnant women, it was somewhat low for pregnant women. The histograms (Figure 3.3.1) show the distribution found in the surveys. The vast majority was above the EAR value, and about 50% were above the 'safe' RDA level of 46 g. For pregnant women, the majority were found below the RDA value.

The theoretical addition of 30 g of ricebean (right side of diagram) was estimated to provide another 5.4 g of protein or 11.7% of the RDA. Since this is a considerable amount compared to the deficiencies recorded, this would have the ability to move a rather large group from marginal to safe levels for non-pregnant women, while the levels for the majority of pregnant women would not be sufficient.

3.3.2 Lysine

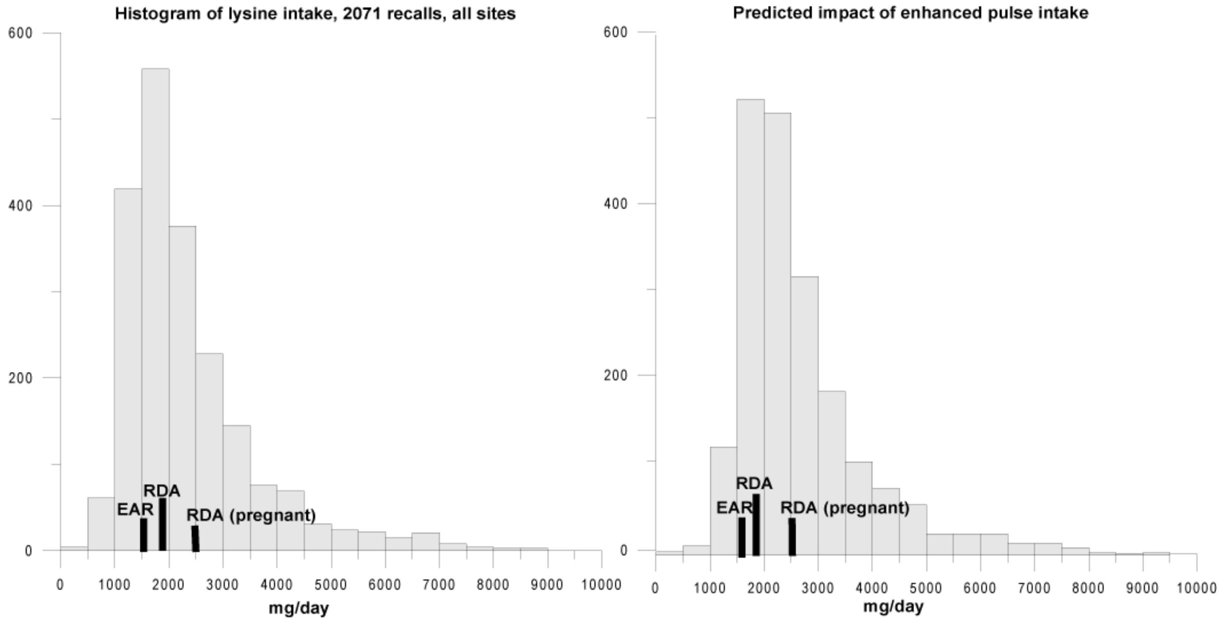

Figure 3.3.2: Actual and predicted lysine intake

The values of lysine intake have been included in the analysis, since ricebean is assumed to be superior to most other pulses in its amino acid profile, and since the mean lysine values in the survey were found to be more marginal than those of other essential amino acids. 43.4% of the individuals in the survey were below the RDA (Figure 3.3.2), while the predicted impact of adding 30 g of ricebean would provide an additional 342 mg of lysine or 18.4% of the RDA, bringing the number below RDA down to less than 15%. As with total protein, enhanced pulse consumption would eliminate most deficiencies of lysine for non-pregnant women, while the majority of pregnant women would still be somewhat marginal in supply.

Concerning other essential amino acids, it is assumed that inadequate intakes are rare, since the mean intakes of these were considerably above the recommended values.

Thiamin or vitamin B1 (Figure 3.3.3) showed a notably downward skewed distribution, leaving a large number of individuals below any of the recommended values. Adding 30 g of ricebean to the diet would provide about 13% of the RDA for non-pregnant women and would have the potential to move the majority, but not all, above the EAR, and also a substantial number above the RDA value.

3.3.3 Thiamin

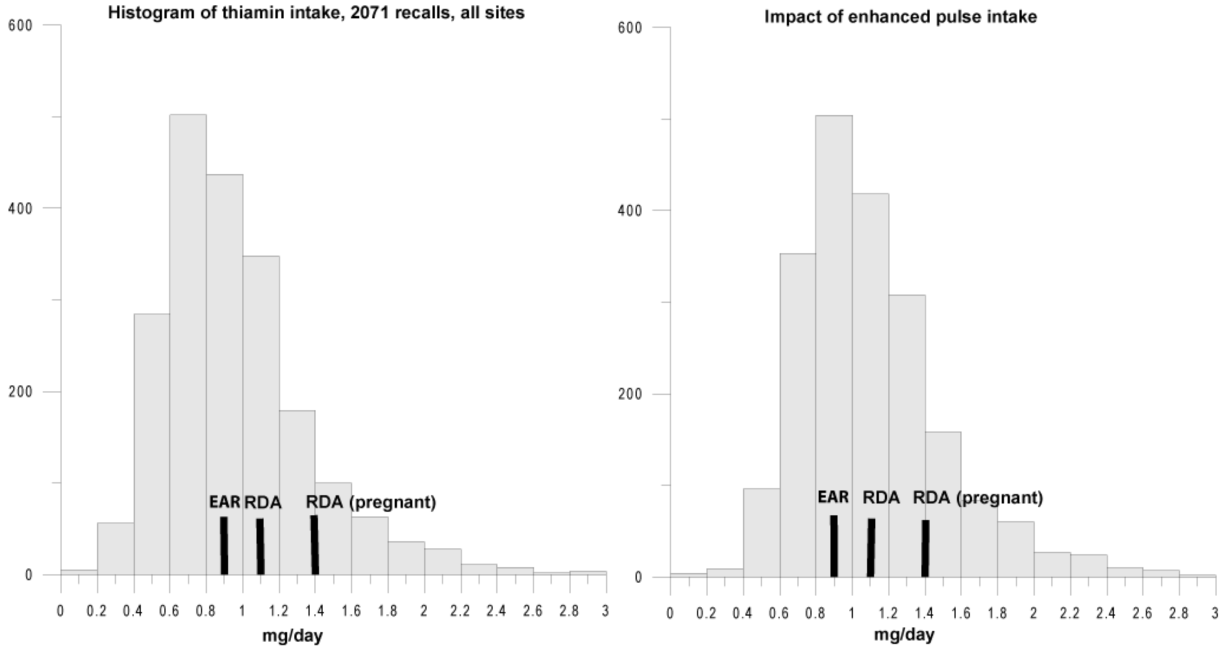

Figure 3.3.3: Actual and predicted thiamin intake

3.3.4. Riboflavin

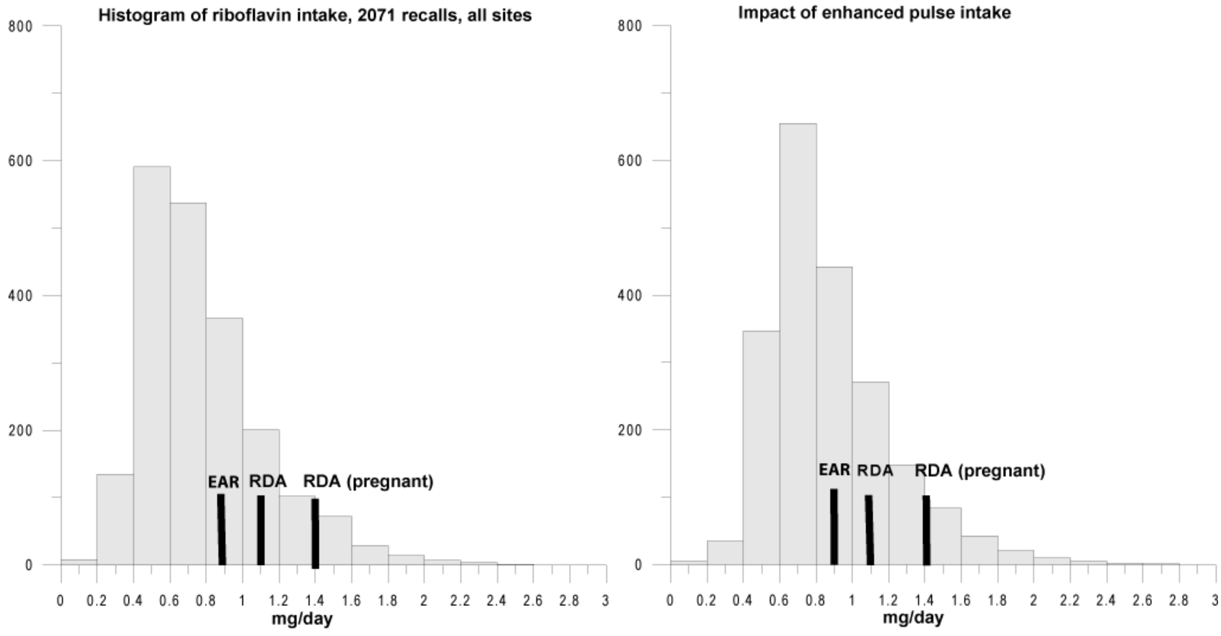

Figure 3.3.4: Actual and predicted riboflavin intake

The recorded intakes of riboflavin or vitamin B2 (Figure 3.3.4) were much similar to those of thiamine. The downward skewed distribution left a large group below the recommended values although the mean intake did not indicate a serious situation. Adding 30 g of ricebean to the diet would provide about 8% of the RDA for non-pregnant women and would potentially move a number of women closer to recommended values but still 78.5% would remain below the RDA, and only about 10% would meet the requirements for pregnant women.

3.3.5 Niacin

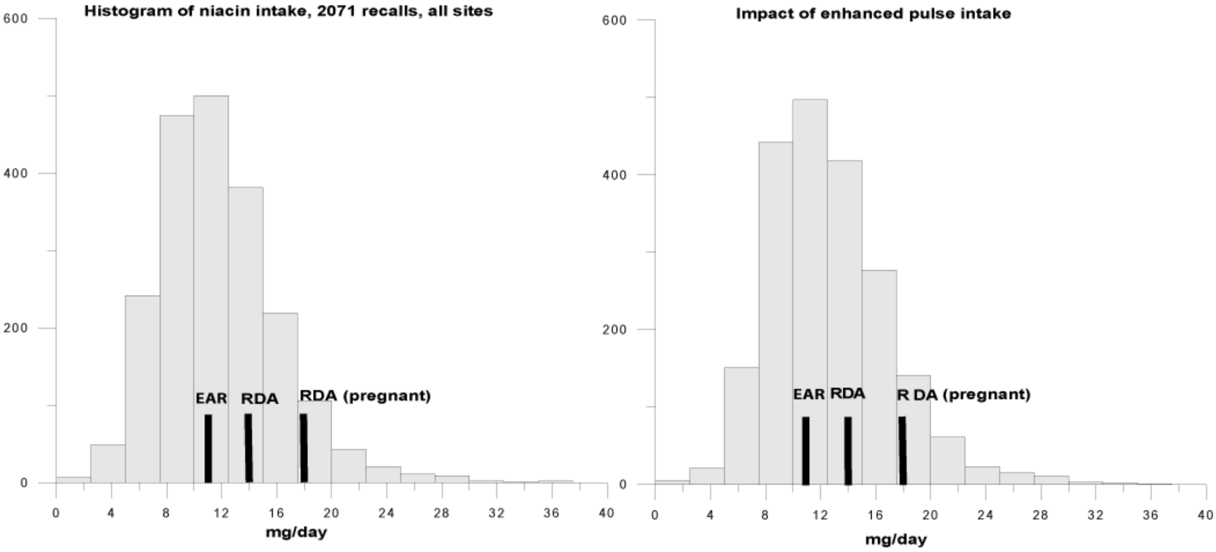

Figure 3.3.5: Actual and predicted niacin intake

Niacin or vitamin B3 intake (Figure 3.3.5) was as a mean not as marginal as for thiamine and riboflavin, and the distribution was not quite as skewed. However, about one third of the women were below the DRI, leaving half of them in potentially deficient status. Adding 30 g of ricebean to the diet would provide about 6% of the RDA for non-pregnant women, and thereby produce a shift to the right in the distribution, from 27.6% to 33.6% being above the RDA value.

3.3.6 Pantotenic acid

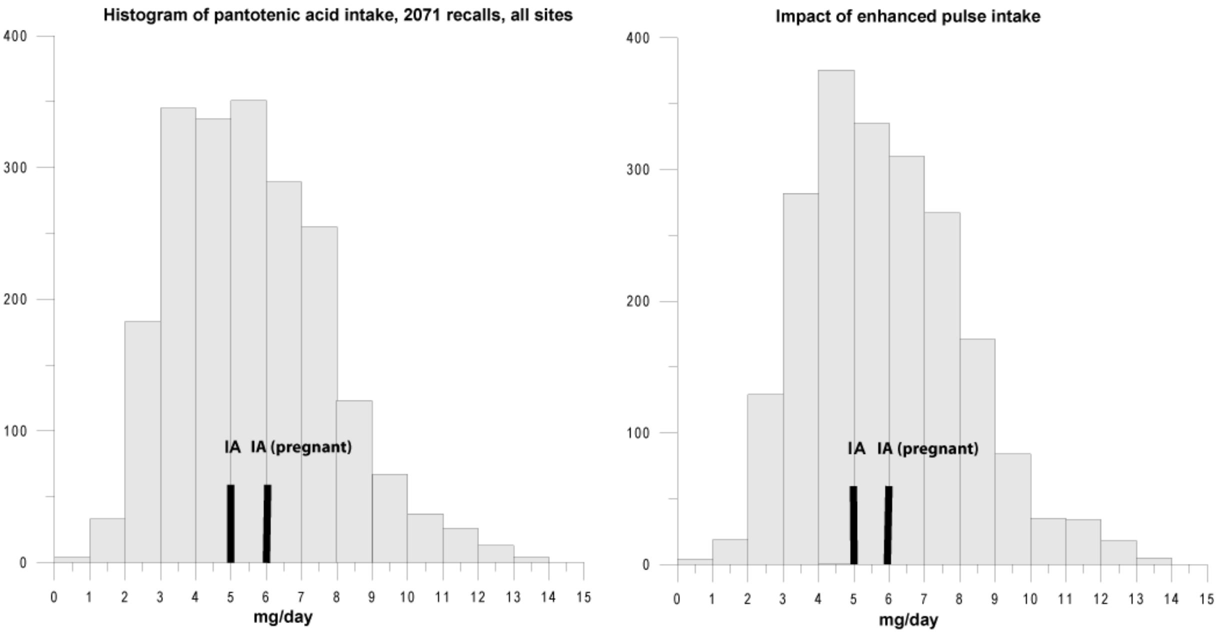

Figure 3.3.6: Actual and predicted pantotenic acid intake

The distribution of intakes of pantotenic acid – vitamin B5 (Figure 3.3.6) was, like niacin, less skewed than for the above mentioned B vitamins, and the level of inadequate intake less severe. Adding 30 g of ricebean to the diet would provide an additional 6% of the IA value for non-pregnant women, but about 39% of the women would still be below the IA.

3.3.7 Pyridoxine

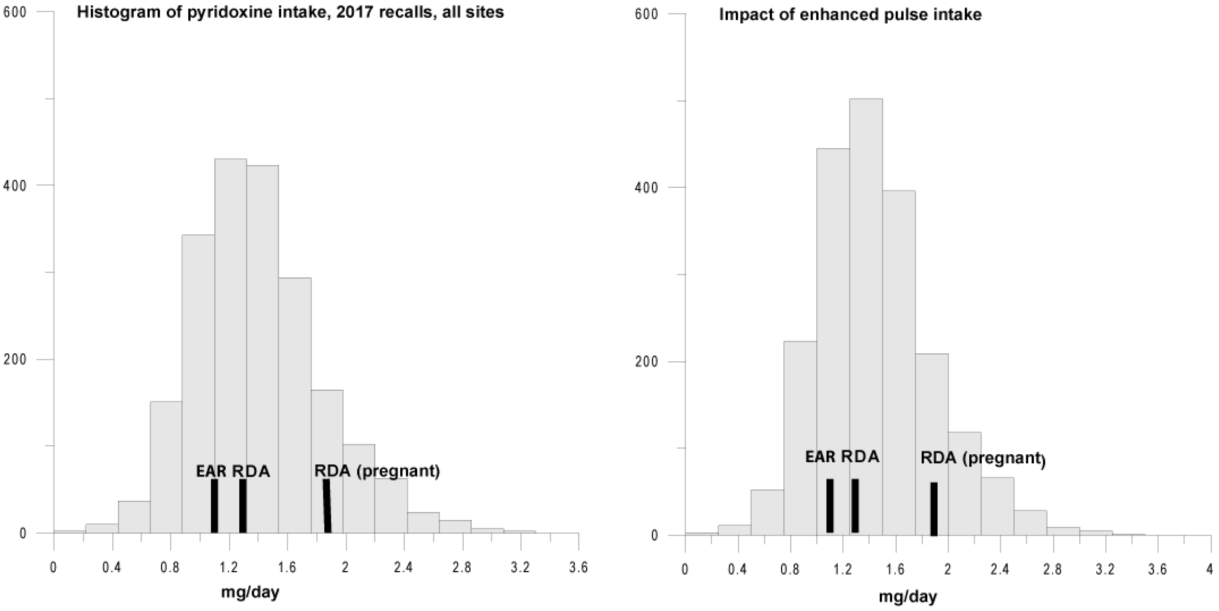

Figure 3.3.7: Actual and predicted pyridoxine intake

Pyridoxine or vitamin B6 intake showed nearly a normal distribution (Figure 3.3.7) and a majority of the women were getting sufficient of this nutrient. The content of 30 g of ricebean would potentially add about 3.2% of the RDA for non-pregnant women, and although the deficiency was limited, this was only enough to raise the women in above the RDA from 55.5% to 59.2%. For pregnant women, pyridoxine is still a major concern, and any realistic increase in bean consumption would not be sufficient to meet the requirements. As mentioned, the data from the Japanese Sugiyama Food Composition Database (Anon, 2004) would suggest that other pulses than ricebean would be better for prevention of B6 deficiency.

3.3.8 Folate

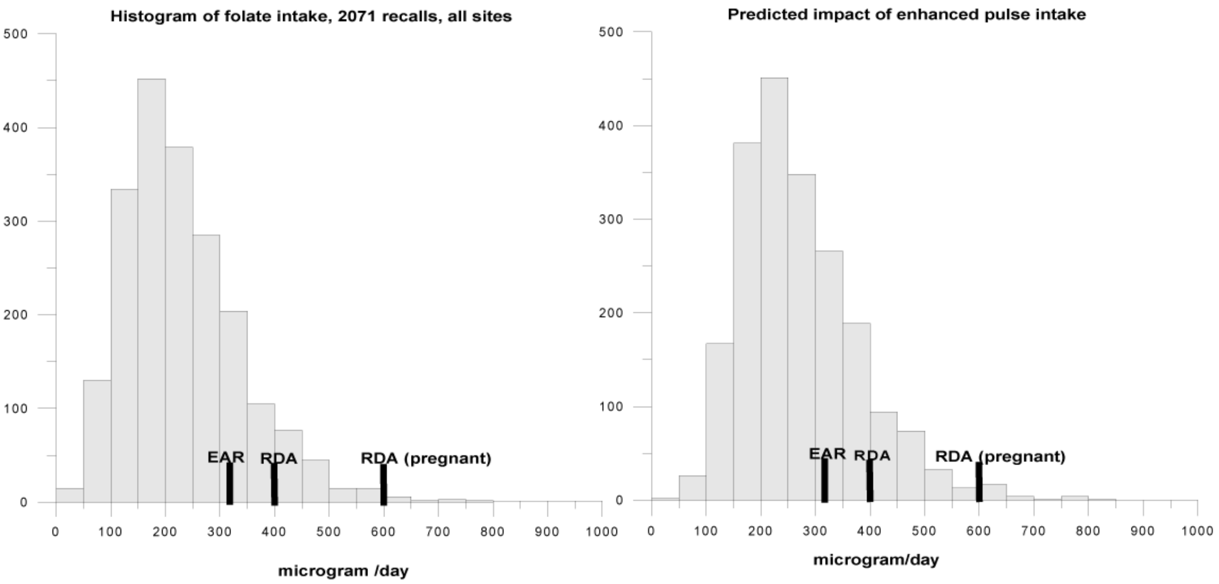

Figure 3.3.8: Actual and predicted folate intake

The mean intake of folate found in the dietary surveys was worse than the other B vitamins and severely below recommended values (Figure 3.3.8). This is a matter of concern because folate is particularly important during pregnancy, for the prevention of neural tube defects.

Pulses including ricebean are relatively good sources of folate, and thereby potentially good 'gap-fillers'. The recorded levels of folate intake in the surveys were highly insufficient for most of the women, and in particular for those who were pregnant, only a fraction would meet the recommended value for pregnancy. Adding 30 g of ricebean would provide another 10% of the RDA for non-pregnant women. While this would be desirable, the level of folate malnutrition was so severe that 88% would still be well below RDA, and in case of pregnancy, nearly all would be in a risk group in terms of folate supply. So ricebean has a good potential but not good enough to meet the needs alone. Other good sources of folate, such as green leafy vegetables should be promoted in addition to pulses.

3.3.9 Potassium

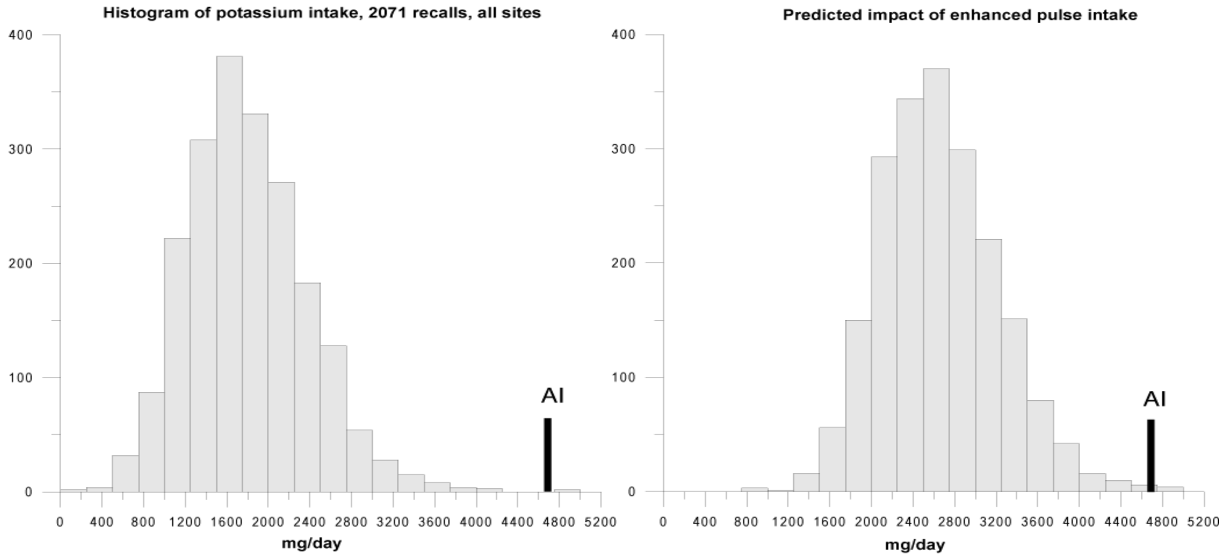

Figure 3.3.9: Actual and predicted potassium intake

As already noted, potassium values found in the study were very low (Figure 3.3.9). When it comes to the distribution, only nine records were found where individuals were calculated to consume more than the daily AI. The rest were far below the recommended values. Ricebean, like other pulses, is rich in potassium and an additional 30 g of potassium would provide about 860 mg or more than 18% of the daily recommended intake. In the diagram, it should be very obvious how this is inducing a substantial shift in the distribution. However, this would only move a fraction of the women in the survey above the recommended daily intake. As with folate, strengthening the supply of pulses would be very beneficial, but due to the severe deficiency of the nutrient, this would not be enough, and increased intake of other potassium rich food (vegetables, fruit) would be needed to meet the recommendations.

3.3.10 Calcium

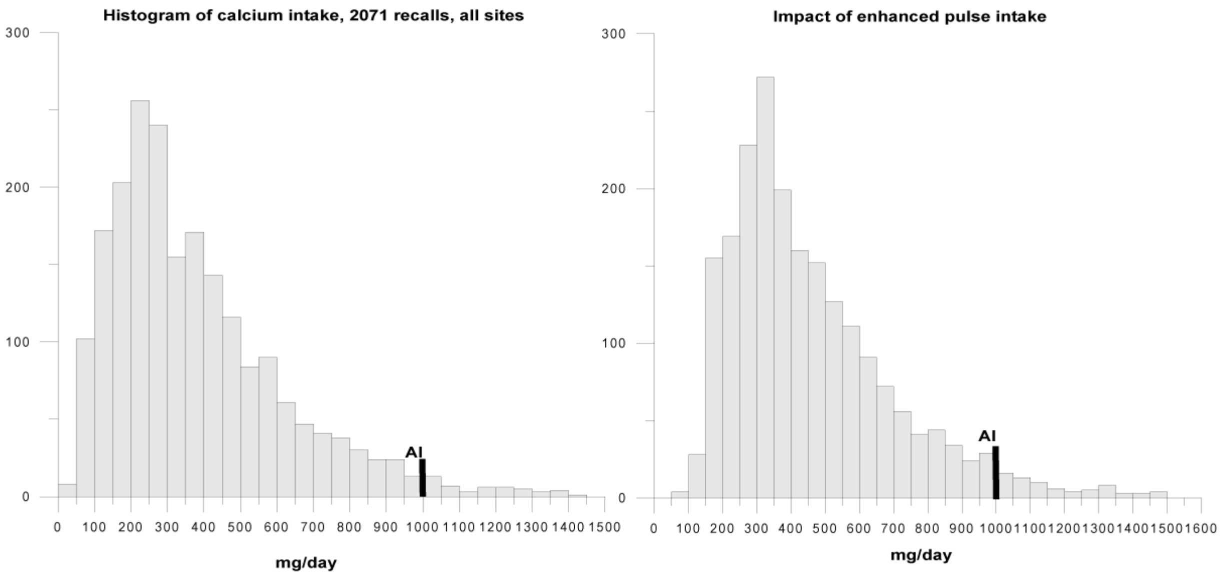

Figure 3.3.10: Actual and predicted calcium intake

Like folate and potassium, the calculated intake of calcium was very low in the dietary survey (Figure 3.3.10). Not only the mean value, but almost all daily intakes were below the recommended AI value. Ricebean is the best of all pulses found in the analysis with respect to calcium content and is assumed to have a significant potential to raise the intake of calcium. However, the recorded deficits were even worse. Adding 30 g of ricebean would provide 79 mg calcium or about 8% of AI, moving the distribution curve to the right but not sufficient to raise the percentage above the recommended value from 2.4% to 3.6%. It may be hypothesized that increased ricebean production would also lead to indirect strengthening of the nutritional security concerning calcium, by means of increasing the production of dairy produce, since this is the most concentrated source of calcium in the diet. For pulses as well as milk products, the problem is that the total share of the diet presently is too marginal to meet the vast undersupply of calcium.

3.3.11 Iron

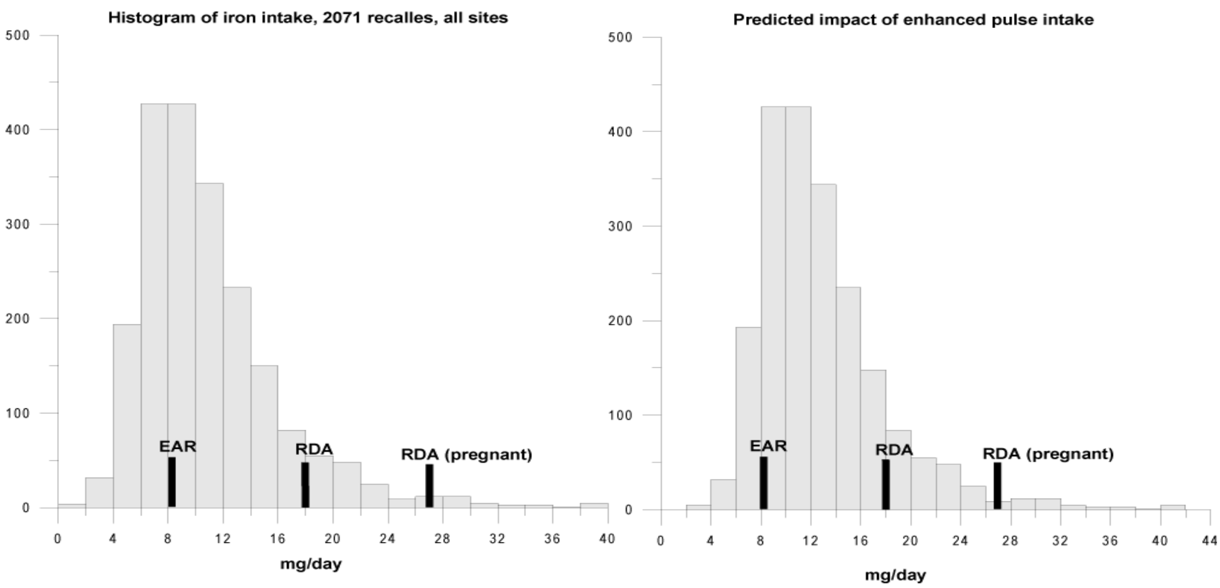

Figure 3.3.11: Actual and predicted iron intake

Concerning iron (Figure 3.3.11), there are large differences in needs between individuals, and thereby a large spread between the recommended values. In the dietary survey, a majority of the women were found to be between the EAR and the RDA for non-pregnant women. Only few were consuming safe levels for pregnant women. The total iron content in ricebean used in the calculations is 6.7 mg/100 g (Mohan & Janardhanan, 1994), meaning that another 30 g of ricebean would provide 2 mg or about 11% of the RDA for non-pregnant women. This would move most of those below the EAR value in the survey to above EAR and closer to RDA, so a rather big reduction in the number of those at risk would be forecasted to end in a less risky situation. For pregnant women, the RDA is much higher, 27 mg/day, and a 30 g increase in ricebean consumption alone would be sufficient for only few to be in a safe category.

It should be noted that the use of the total value for iron can be assumed to exaggerate to potential of increased pulse consumption, since all of this iron will not be bio-available. On the other hand, it may be that the iron values published by Mohan & Janardhanan (1994) are in a low range; if the national Japanese Food Tables (Anon, 2004) are basis of the calculation, 30 g of ricebean would provide more than 20% of RDA.

3.3.12 Zinc

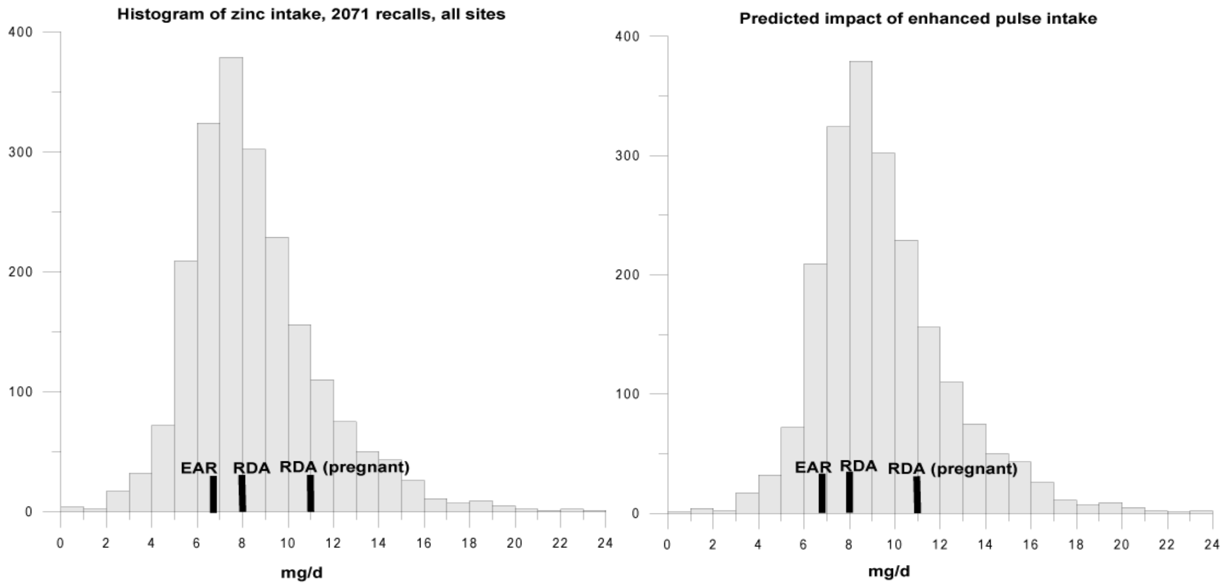

Figure 3.3.12: Actual and predicted zinc intake

The distribution of zinc (Figure 3.3.12) intakes reflect that the mean intake was above the RDA of 8 mg per day, but roughly 15% were below the EAR value. For pregnant women, the majority was below the RDA, but more than 10% were above, indicating that the predicted zinc status was better than the iron status. Adding 30 g of ricebean to the diet would have the potential to raise the intake by about 1 mg per day, or about 11.6% of the RDA for non-pregnant women. This would shift the distribution in a manner that would bring a substantial number from marginal to safe status for non-pregnant women, while a majority of pregnant women would still be below the RDA for this group. So although the zinc concentration of ricebean is not very high, the level of inadequate intake found in the surveys was also moderate, and thereby ricebean can make a positive change in zinc intake. However, the calculations are based on total content of ricebean. Therefore, the same considerations about the bioavailability of zinc should be made as for iron.

4. Indirect effects of ricebean cultivation

Apart from the direct role ricebean plays and can play through human consumption, there are significant indirect benefits. Ricebean is an excellent cover crop, protecting land from soil erosion, and it is effective in suppressing weeds in maize-ricebean intercrops. It is one of the options for protecting and stabilising terrace risers, the use of which for cropping in hill farming substantially increases the area available for cultivation. Its nitrogen fixing capacity was documented by Rerkasem *et al.* (1988) and Rerkasem & Rerkasem (1988), and has the dual effect of increasing yields of the intercrop as well as improving the nitrogen flow in local food systems. All these ecological services are likely to increase general system productivity and food security.

Furthermore, ricebean crop residue is a valuable fodder which is known to increase the productivity of dairy cows and of small ruminants, thereby indirectly adding to the supply of animal source foods. Since the consumption of meat is very low, milk products are especially important in terms of vitamin B12 and calcium, since the supply of these two nutrients are below RDA in all areas. Milk products are the main source of B12 and an important source of calcium, providing 182 mg of the mean value of 308 mg per day (compared to RDA of 500) in the dietary recall.

5. Conclusion

Ricebean is a traditional crop which is well suited for existing, local recipes and fits into the daily diet without changes. In addition it has properties suitable for other, locally known and popular food items.

The study has documented that ricebean has nutritional traits that are comparable to other low fat grain pulses in most respects. It is a good source of high quality protein, having a very favourable amino acid profile, and contains more of several minerals than most other grain pulses. That makes it an especially good source of calcium, magnesium, potassium and iron. In terms of vitamins, it is a very good source of vitamin K but to some extent lower than other pulses in some of the B vitamins. It is free from allergenic and toxic substances.

The dietary survey revealed that there were substantial differences in the diets between the study sites although the dominance of rice as staple food was common for all. Still, the pattern of malnutrition was basically the same. While mean values of energy and protein supply was reasonable, there were predicted problems with the supply of micronutrients. The mean values suggested that the main problems were vitamin A, B9, B12, D and E, and among minerals the most important problems were calcium, potassium and iron. Thereby ricebean has a particular match with recorded nutritional risk problems with respect to folate, calcium, potassium and iron.

However, the analysis of intakes showed that the distributions were skewed downwards especially for the B vitamins so that large groups of women were consuming these nutrients far below the recommended values.

The theoretical impact of increased intake of ricebean was based on the assumption that a daily increase of 30 gram of ricebean is a realistic measure of what people would eat if it was not constrained by supply or purchase power. It may be disputed whether this assumption is accurate, but the general conclusions would not differ substantially even if the amount was raised to twice this amount, and our conclusion will also have to acknowledge that ricebean must be seen as a *food item*, not only a source of nutrients. There will be a limit to the amount of pulses any individual will prefer to eat.

The impact analysis showed that the largest effect of increased intake of ricebean *as measured by moving numbers from below to above recommended values* (Table 6) were in the case of the nutrients where malnutrition levels were slight, as in the case of protein and lysine. For nutrients where widespread and severe levels of malnutrition were found in the dietary survey, for instance calcium and potassium, increased supply of ricebean was not enough to move more than a small fraction from below to above the recommended values, despite relatively good concentrations of these nutrients in ricebean.

Table 6. Percentage of recalls above the recommended values.

	% of recalls above RDA/IA	% of recalls above RDA/IA with 30 g ricebean added to daily intake
Protein[1]	50.4	66.6
Lysine[1]	56.7	75.8
Thiamin [1]	29.7	44.0
Riboflavin [1]	15.7	21.5
Niacin [1]	27.6	33.6
Pantotenic acid[2]	57.0	61.0
Pyridoxin [1]	55.5	59.2
Folate [1]	8.0	11.6
Potassium[2]	0.4	0.6
Calcium[2]	2.4	3.6
Iron [1]	8.6	12.6
Zinc [1]	49.8	68.4

[1]RDA for non-pregnant women, [2]IA for non-pregnant women.

However, the increased consumption of ricebean would 'shift the distribution curve to the right' and provide *a substantial change in the level of severity of undernutrition* although not enough to meet the recommended values. Thereby the percentages without or with increased ricebean intake may be deceptive.

It is beyond the scope of this work to conclude on the specific health outcome of moving from slighter deficiencies to above recommended values compared to reducing severe deficiencies to less severe, and it cannot be judged on a general basis since this will relate not only to specific nutrients but also to different health aspects of each nutrient and even synergistic effects of several nutrients. Therefore the general conclusions that can be made will be that

- ricebean has substantial potentials to match expected nutritional problems in the region, and thereby food security
- some nutritional problems are too severe to be met with a realistic amount of increased consumption of ricebean (and other pulses) only
- in the cases of severe deficiencies, increased supply of other nutrient dense food items (vegetables, animal source foods) are pertinent in addition to pulses
- the balance between rice and other staple foods is also of substantial importance to the overall adequacy of the diets and should be taken into consideration in local nutritional strategies

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Appendix 1

Categories in the Indian food table from WF2

Apple
apple, sugar
banana, ripe
bean cake, fried
bean, cluster
bean, field
bean, french
bean, horse
bean, kidney
bean, mung
bean, mung, mashed or flour
bean, mungo, mashed or flour
bean, scarlet runner
beef, all types
biscuits, salty
bitter melon
bread, white
butter, buffalo, clarified
Buttermilk
castor oil
Chickpea
chickpea, green
chickpea, mashed or flour
chile, green
chili powder, red
coconut, dried
Cookies
coriander leaf powder
Cowpea
cowpea, mashed
Cucumber
cumin seeds
Curds
Dock
Egg
Eggplant
fish
garlic
ginger root, fresh
Goat
gourd, bottle
gourd, ridge
gourd, snake
grapes, pale green
horseradish
hydrogenated oil
leaf, betel
leaf, chickpea
leaf, coriander
leaf, cowpea
leaf, fenugreek
leaf, hibiscus
leafy vegetables, other
lemon, limes
Lentil
linseed oil
linseed seeds
maize, grain or flour, hyv
maize, grain or flour, local
maize, green
mango, green
mango, ripe
melon, musk, other fruits
milk, buffalo
milk, cow
milk, goat
millet, finger, grain or flour
millet, pearl, flour, hyv
millet, pearl, flour, local
millet, pearl, hyv
millet, pearl, local
mustard seeds
Okra
onion w/stalks
Onions
Orange
palm sap beverage, fermented
palm sap beverage, sweet
Peanut
peanut oil
pigeon pea
pigeon pea, mashed or flour
Plums
poppy seeds
Pork
Potato
Poultry
Pumpkin
rice flakes
rice, grain or flour, hyv
rice, grain or flour, raw, local,milled
rice, hyv, paddy
rice, local, paddy
safflower oil
safflower seeds
sago palm starch
salt
semolina
sesame oil
sesame seed
sorghum, grain or flour, hyv
sorghum, grain or flour, local
sorghum, green
soybean oil
spices, mixed
spinach, cooked
spinach, raw
Sugar
sugar, brown
Sugarcane
sugarcane juice
sugarcane syrup
sunflower seeds
sweets
tamarind
tomato, green
tomato, ripe
vermicelli
watermelon
wheat, flour, local or hyv
wheat, flour, maida
wheat, hyv
wheat, local

Appendix II

Nutritional parameters calculated in WF2

enerc_kcal	Kilocalories	vitb12	Vitamin B12 in micrograms
a_kcal	Kilocalories from animal sources	pantac	Pantothenic Acid in milligrams
procnt	Protein in grams	ca	Calcium in milligrams
a_protein	Protein in grams from animal sources	p	Phosphorus in milligrams
mfp_protei	Protein in grams from meat, fish and poultry (does not include milk and eggs)	mg	Magnesium in milligrams
Fat	Fat in grams	k	Potassium in milligrams
chocdf	Carbohydrate by difference in grams	na	Sodium in milligrams
fasat	Saturated fatty acids in grams	fe	Iron in milligrams
fams	Mono saturated fatty acids, in grams	mfp_fe	Iron from meat/fish/poultry in milligrams (does not include milk or eggs)
fapu	Poly unsaturated fatty acids, in grams	zn	Zinc in milligrams
chole	Cholesterol in milligrams	cu	Copper in milligrams
Fib	Fiber, method of determination unknown (dietary fiber), in grams	mn	Manganese in micrograms
sucs	Sucrose in grams	trp	Tryptophan in milligrams
phytac	Phytate in milligrams	thr	Threonine in milligrams
vita	Vitamin A in retinol equivalents	ile	Isoleucine in milligrams
a_vita	Animal source vitamin A in retinol equivalents (micrograms)	leu	Leusine in milligrams
vitd	Vitamin D in micrograms	lys	Lysine in milligrams
vite	Vitamin E in tocopherol equivalents	met	Methionine in milligrams
vitc	Vitamin C in milligrams	cys	Cystine in milligrams
thia	Thiamin in milligrams	phe	Phenylalanine in milligrams
ribf	Riboflavin in milligrams	tyr	Tyrosine in milligrams
nia	Niacin, preformed in milligrams	val	Valine in milligrams
vitb6	Vitamin B6 in milligrams	arg	Arginine in milligrams
fol	Folate in micrograms	his	Histidine in milligrams

Appendix III

Baseline survey checklist

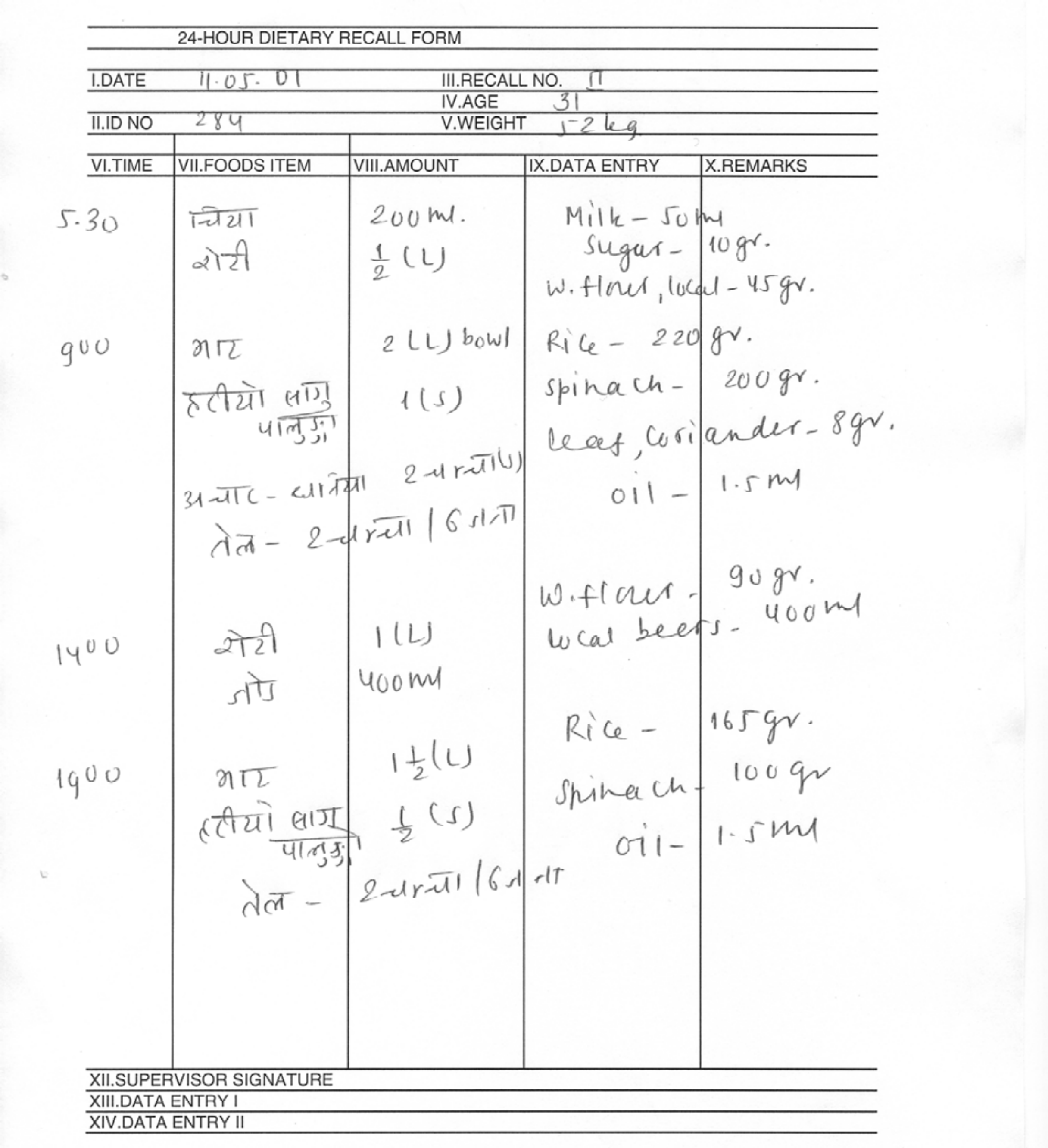
FOSRIN DIETARY SURVEY 2007

1	Woman ID number	
2	Location	
3	Date (day month year)	
4	Field worker code	
5	Name of women	
6	Name of the head of household	
7	Age of women (completed years)	
8	Household status: male headed = 1, female headed = 2	
9	Number of family members	
10	Weight (kg)	.
11	Height (cm)	
12	Parity (number of deliveries)	
13	Condition of woman (1= non pregnant, 2= pregnant, 3= lactating first 6 months), 4 = lactating beyond 6 months)	
14	Physical activities (1= light, 2= moderate, 3= heavy)	
15	Non-smoking = 1, smoking = 2	
16	Home pulse/beans production within last 2 years (1= rice bean, 2=no, 3 =others, specify)	
17	Method of pulse/beans preparation (1= soaking, 2=sprouting, 3=boiling 4= pressure cooking, 5=frying, 6=combination, 9=not applicable)	

18	Main sources of livelihood (1=service, 2=agriculture, 3=business, 4=remittances, 5= other, specify?)	
19	Own staple grain production sufficient for how many months per year?	
20	Estimated monthly expenditure, all items (Rupee)	
21	Do you consider your household economy 1 = poor 2 = medium 3 = rich	

Appendix IV.

Example of filled in data sheet.



24-HOUR DIETARY RECALL FORM

I.DATE 11.05.01 — III.RECALL NO. II

IV.AGE 31

II.ID NO 284 — V.WEIGHT 52 kg

VI.TIME	VII.FOODS ITEM	VIII.AMOUNT	IX.DATA ENTRY	X.REMARKS
5.30	चिया	200 ml.	Milk – 50 ml	
	रोटी	½ (L)	Sugar –	10 gr.
			W. flour, local – 45 gr.	
900	भात	2 (L) bowl	Rice – 220	gr.
	हरियो साग पालुङ्गो	1 (S)	spinach –	200 gr.
	अचार – धनियाँ	2 चम्चा (L)	leaf, Cori	ander – 8 gr.
	तेल – 2 चम्चा / 6 जना		oil –	1.5 ml
			W. flour –	90 gr.
1400	रोटी	1 (L)	local beers –	400 ml
	जाँड	400 ml		
			Rice –	165 gr.
1900	भात	1½ (L)	Spinach –	100 gr
	हरियो साग पालुङ्गो	½ (S)	oil –	1.5 ml
	तेल –	2 चम्चा / 6 जना		

XII.SUPERVISOR SIGNATURE

XIII.DATA ENTRY I

XIV.DATA ENTRY II