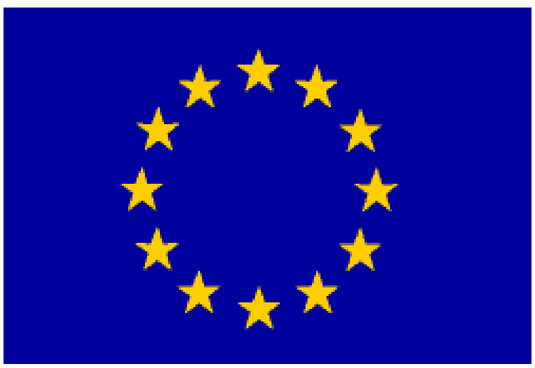
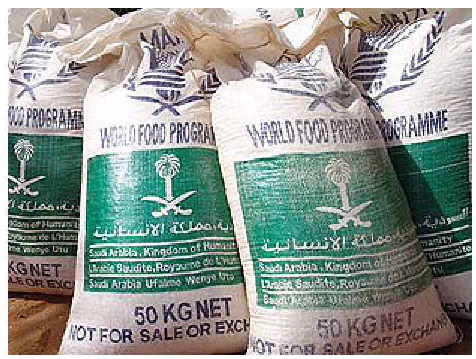
Nutritional Measure of Food Aid Deliveries

DRAFT REPORT

Canadian International Development Agency | Agence canadienne de développement international





By Colleen Doak and Shanta Marapin

Contact:
Colleen M. Doak, PhD
Assistant Professor
VU University Amsterdam
FALW, Department of Health Sciences
Nutrition and Health
De Boelelaan 1085
1081 HV Amsterdam
colleen.doak@falw.vu.nl
Phone: +31 20 598 3502
Fax: +31 20 598 6940

Acknowledgements

This paper was written as part of a WFP project, which was supported by the European Commission and Canada. We would like to thank the European Commission and Canada for their support of the project. We would also like to thank collaborators from the World Food Programme who contributed to the thinking and formulation of the measures shown here, including Vera Mayer, Ms.Pushpa Acharya, Ms.Editth Heines, Ms.Ester Fiorito, Ms.Simonetta Basile, Ms.Maria Teresa Silvi, Ms.Tina Van Den Briel, and Ms. Cora Best. I would also like to give special thanks to Henk-Jan Brinkman for his detailed comments that have helped to improve the analysis and helped to clarify this draft. Finally we would like to thank my colleagues at the VU University, Lothar Kuijper for his formulation of the ratio concept and Michien de Boer for his input in the score and comments on the principle components analysis.

WFP

World Food Programme

Table of Contents

Tables

1. Introduction

1.1 Evaluating food aid

Food aid has previously been measured in metric tons or in monetary value, such as dollars or euros (see internal WFP document, A proposal to develop Nutritional Measure of Food Aid Flows). However, in the current environment of inflation and changing food prices, it is important to have alternative methods of assessing food quality. Furthermore, abundant evidence has shown micronutrient intake is related to child growth, cognitive development, morbidity and mortality. Food quality, particularly micronutrient sufficiency, is thus vitally important to the emergency food aid context.

1.2 Food Labeling and Profiling

A system of scoring foods is needed which includes the vital macronutrient (energy protein and fat) needs as well as minerals and micronutrients. Previous methods for nutritional profiling have been used. These assess diet or food quality provide examples, including food labeling systems and nutrient density scores. The quality of food has been assessed through food labeling systems. These systems, described by Drewnowski, have the goal of guiding shoppers to make healthy choices (Drewnowski, 2005). One of the earliest such examples was the University of Michigan grocery shopping guide as a point-of-sale guidance system (Mercer et al, 1988). The "Choices" profiling system originates from the Dutch "Choices" labeling and provides a logo for food products that fit a set criteria (Ik Kies Bewust report 3.2, 2007). In the UK a system stoplight program was developed (Snelling, 2007). These food profiling systems evaluate foods based on an evaluation of best practice and the population health concerns, largely focusing on overweight, obesity and chronic disease risks. However, micronutrient contribution is also considered. Because of the importance of milk to calcium, for example, the Choices food labeling system allows for more flexible standards regarding fat and saturated fat content for milk as compared to other foods. While labeling and logo approaches are focused on assisting shoppers in making healthy choices, they provide useful methods that can be adapted to the emergency food aid context. Namely, the score should be evidence-based, focusing on the priority nutritional concerns for the target population e.g. food aid recipients, and should evaluate foods in a manner that is sensitive to the context of how a food aid is delivered.

1.3 Guidelines for populations dependent on emergency food aid

Nutritional needs and guidelines for populations dependent on emergency food aid have been clearly identified by the World Food Programme (WFP) in two joint publications. In *Food and Nutrition Needs in Emergencies*, a publication with United Nations High Commissioner for Refugees (UNHCR), United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), WFP provides specific guidelines for the energy and macronutrient needs for populations entirely dependent on food aid as 2100 kcal per person per day, 17 percent energy from fat and 10-12 percent of energy from protein. In a separate joint statement by the WHO, WFP & UNICEF (2002), 15 micronutrients are identified as most important to the context of emergency food aid. The 15 micronutrients used are: vitamin A, vitamin D, vitamin E, vitamin C, thiamine, riboflavin, niacin, vitamin B6, vitamin B12, folic acid, iron, zinc, copper, selenium, and iodine. The score for assessing food aid quality should assess how well a food commodity contributes to these 15 micronutrients as well as energy, protein and fat.

1.4 Existing Food Quality Scores

A handful of approaches have been informative to developing a score for assessing food quality based on the above 18 nutrients. Kant (1996) describes a number of dietary quality indexes. One of the most useful approaches is the method of Madden and Yoder (Madden and Yoder, 1972) of assessing foods based on the ratio of a given nutrient contained in a food relative to the recommended daily allowance (RDA) for that nutrient. This information is then adapted to create a mean adequacy ratio (MAR), a concept that allows for assessing foods based on their mean contribution of micronutrients. A second approach, helpful to an emergency food aid perspective, was developed by Lachance (1986). This method is the Calories for Nutrient Score (CNF) which averages, over a number of nutrients, the energy density of a food over the mean percentage daily value for 100 grams of a food. While the energy density aspect of this score is not helpful to the emergency food aid condition, the denominator is informative. In particular, a scoring that is fixed to weight, per 100 grams, rather than a 2100 kilocalorie amount, has two main advantages. First, a score based on weight in grams can be scaled up to metric tones given and received. Most importantly, however, an approach fixed to weight rather than kilocalories allows for assessment of commodities that do not contribute energy, such as iodized salt.

1.5 Mean Adequacy Ratio

Drewnowksi et al (2005) has identified a limitation of the mean adequacy ratio (MAR), namely not all foods are consumed reasonably consumed at the set 2100 kilocalorie quantity. This concern relates also to a score based on 100 gram quantities. For example, iodized salt is usually included in food aid rations in amounts limited to 5 grams per person. If quality is assessed based on 100 grams, the total daily value would be 20 times the minimal requirement. The MAR score for iodized salt, even after being averaged over the 18 nutrients, would be 1.1 times the minimal requirements met for all nutrients. However, in reality salt contributes only to one of the 18 identified nutrients. Adopting ration amounts as a “usual portion size” can be used to apply upper limits that each food can contribute. Adjusting the score based on actual ration quantities used by the World Food Programme, rather than 100 gram amounts, provides a more realistic estimate of how food aid contributes to nutritional requirements. There is also a need to identify other methods for limiting the contribution of a single nutrient to the total score.

1.6 Underlying assumptions and limitations

The concept of the Mean Adequacy Ratio, such as described above, was originally developed to evaluate the food stamps programme in the United States. It can be used to asses the nutritive value of foods. While it does not comprehensively assess food quality, we can use the concept of minimal requirements as an alternative measure for food aid that assesses multiple nutrients. There are a number of underlying assumptions that limit the validity of the score. First, the reference values, such as recommended daily allowances or in our analysis, minimal requirements met, are based on a reference individual. In this case, the reference individual is an adult requiring 2000 kilocalories.

This assumption does not take into account the special nutritive needs of vulnerable groups, such as pregnant women or children. Furthermore, the assessment of food aid given in tons requires scaling up existing scores from foods consumed by individuals per day to food aid distributed to groups in tons per year. To the extent that multiple foods will be assessed together, there are limitations in how to interpret those results. While a mathematical score such as the Mean Adequacy Ratio can be used to create averages of requirements met, in reality nutrients are not distributed evenly in foods.

2. Aims and Objectives

The main aim of this report will be to assess the quality of food aid focusing the priority nutrients identified in World Food Programme publications. This score will be designed to compare food commodities against each other, and must be potentially scaled up to evaluate food commodities given in tons. First, we will assess food commodities based on their contribution to minimal requirements met (MRMs), in 100 gram quantities. Secondly, we will test a score-based approach that adjusts the original score based on the actual ration quantities. Third, we will convert from the score, based on average MRMs per 100 grams into the mean MRMs contributed per ton of food aid. Each scoring system above will provide a score for each of the nutrients, by commodity and also averaged over multiple commodities. An additional analysis will test the impact of limiting the contribution of nutrients contributing extremely high (more than 100%). While some nutrients may contribute disproportionately to a high score, we will also identify the nutrient least present in food aid. This nutrient, we call the "limiting nutrient" limits the number of people who could theoretically have all minimal requirements met, from all nutrients, through the food aid deliveries. Finally, we will analyze the clustering of nutrients together in foods using principal component analysis to develop possible approaches for summarizing the data. Approaches will be tested for using limiting, mean, maximum, and principle components to develop a simple code to describe the most relevant information. This analysis will help in determining whether some nutrients results can be combined or ignored in the analysis without losing information.

3. Methodology

3.1 Overview of Methods

In this report we test methods for assessing the nutrient quality of food aid that can be integrated into a score. The first score is based on the MRM's provided in a 100 gram amount, the second will be based on MRMs provided by that food in rations. These scores will be compared to an alternative measurement that assesses quality of food aid based on the mean number of requirements met per ton of food aid. In order to test each method as a possible approach for developing a food quality score, we use actual examples from food aid commodities given and received. The recipient countries used in this example are Ethiopia and Sudan. The quality of donations given by the United States and the European Commission will be tested. This process will help test the utility of the different methods for assessing food quality in order to inform a decision about which approach is most appropriate for a score to assess food quality in the context of emergency food aid. Below we describe the details of the methodology for the food scores and the examples to be used. Finally, we describe the methodology used to explore principal component analysis as a methodology for making further adjustments to the existing score.

3.2. Nutrients included

Ultimately, this score will summarize the average recommended intakes based on energy, protein, fat and the 15 micronutrients identified as most important to the emergency food aid context. Recommended fat intake used for the score is converted to the grams of fat needed to provide the recommended 17% of energy based on a 2100 kcal diet (40 grams). Protein requirements are based on the lower 10% of energy from a 2100 kcal diet (52.5 grams). Because of the limited number of micronutrients available from NutVal we are not able to include in our score the following 8 micronutrients: vitamin D, vitamin E, vitamin B6, vitamin B12, folic acid, zinc, copper, or selenium. The remaining 7 micronutrients together with protein, energy and fat are shown in Table 1. The minimal requirements of the 10 nutrients included here are the basis for the "minimal requirements met" scores, by 100 grams (MRM1) by the ration amount (MRM2), per ton (MRM3) and per ton adjusted by actual commodity weights (MRM4).

3.3 Minimal requirements met from 100 grams of food commodity (MRM1)

In order to summarize the quality of foods the minimal requirements met are determined first for each of the 10 nutrients identified as priority nutrients and included in the NutVal programme. For each food commodity, the mean requirements met per 100 grams of food commodity (MRM1) are calculated based on the amount of the nutrient in 100 grams divided by the minimal requirements as shown in **Table 1**. MRM1 describes, for each nutrient, the contribution 100 grams of food commodity provides to the daily individual.

Table 1. Minimal requirements

Nutrient	Energy	Protein	Fat	Iron	Iodine	Vitamin A	Thiamin	Riboflavin	Niacin	Vitamin C
Amount	2100 kcal	52.5 g	40 g	41 mg	150 µg	500 µg	0.9 mg	1.4 mg	12 mg	28 mg

MRM1 is calculated for each of the nutrients as follows:

1) MRM1 for energy = Energy $_{100g\ food\ commodity}$/2100 kcal
2) MRM1 for fat= Grams fat $_{100g\ food\ commodity}$/40 grams
3) MRM1 for protein=Grams protein $_{100g\ food\ commodity}$/52.5 grams
4) MRM1 for iron= Milligrams iron $_{100g\ food\ commodity}$/41 milligrams
5) MRM1 for iodine= Micrograms iodine $_{100g\ food\ commodity}$/150 micrograms
6) MRM1 for vitamin A= Micrograms vitamin A $_{100g\ food\ commodity}$/500 micrograms
7) MRM1 for thiamine= Milligrams thiamine $_{100g\ food\ commodity}$/0.9 milligrams
8) MRM1 for riboflavin=Milligrams riboflavin $_{100g\ food\ commodity}$/1.4 milligrams
9) MRM1 for niacin= Milligrams niacin $_{100g\ food\ commodity}$/12 milligrams
10) MRM1 for vitamin C= Milligrams vitamin C $_{100g\ food\ commodity}$/28 milligrams

3.4 Mean MRM1

In order to create a score for each commodity the above MRM1 scores for the 10 nutrients are summed together and averaged for a mean MRM1 score. For every commodity, the mean MRM1 score summarizes the nutrient quality of 100 grams of food commodity across the 10 nutrients included. The mean MRM1 score per commodity is thus calculated as follows:

"Mean MRM1" = $\overline{\textbf{MRM1}}$=(∑ MRM1 Energy + MRM1 fat + MRM1 protein + MRM1 iron + MRM1 iodine + MRM1 vitamin A + MRM1 thiamine + MRM1 riboflavin + MRM1 niacin + MRM1vitamin C) **/10**

$$\overline{\mathrm{MRM1}} = \frac{\sum_{i=1}^{10} X_i}{10}$$

∑ denotes summation

$X_1, X_2, \ldots X_{10}$ denote the individual nutrients X_1 being energy, X_2 being fat, $\ldots X_{10}$ being vitamin C.

3.5 Multiple Commodities MRM1

The mean MRM1 only provides a summary score for a single commodity, providing a summary assessment across the 10 nutrients. However, it is also necessary to summarize the quality of multiple food commodities together to assess the total food aid given and received. Therefore, it is necessary to create an average of the mean MRM1 values for the commodities included together in food aid. This summary measures the mean of the mean MRM1 from multiple commodities. This mean of mean MRM1s will be henceforth referred to as "Mean of Multiple Commodities MRM1." The formula below shows the Mean of Multiple Commodities MRM1 is the Mean MRM1 values averaged across the commodities included in food aid deliveries.

$$\text{Mean of Multiple Commodities MRM1} = \overline{\text{Multiple Commodities MRM1}}$$

$$\overline{\text{Multiple Commodities MRM1}} = \frac{\sum_{i=1}^{n} \overline{\text{MRM1}}}{n}$$

∑ denotes summation
n denotes the number of commodities
$X_1, X_2, \ldots X_n$ denote the individual nutrients X_1 being energy, X_2 being fat, $\ldots X_{10}$ being vitamin C.

3.6 Limiting nutrient contributions

The above analysis does not take into account that some nutrients will contribute disproportionately to mean MRM1 values. Therefore, we further limit the contribution of single nutrients to MRM1. In numbers of requirements met, this limit is equal to 1.0. This cutoff is equivalent to 100% of the minimal requirements met from 100 grams of food. MRMs that a single nutrient can contribute to a commodity's mean MRM1. Thus, the analysis will be run again with this limitation to test the impact of setting limits on the nutrient contribution by restricting the contribution a single nutrient can make to the mean MRM1. This limit will influence all values as all further analysis stems from the MRM1 value for commodities.

3.7 Upper Limits of Ration Quantities

Another limit is not based on single nutrients, but rather foods. The "Mean Multiple Commodities MRM1"counts all commodities equally in the commodities mean. However, not all commodities will contribute equally to meeting the nutritional requirements of the recipient populations. Therefore, after determining the average minimal requirements met from 100 grams of food commodity (mean MRM1), the next step is to adjust the score based on realistic quantities. The MRM1 for each food commodity is weighted to convert the results from 100 grams to ration quantities. The specified quantities listed below are taken from the range of amounts distributed according to Table 2 of Food and Nutrition Needs in Emergencies (UNHCR, UNICEF, WFP and WHO joint publication, November 2002, p.9). The range here is based on options given in 5 food ration examples. Dairy products are not included in the ration tables and therefore excluded from this exercise.

1) Cereals (range from 350 grams to **450 grams**)
2) Pulses (50-**100 grams**)
3) Oil (25-**30 grams**)
4) Fish and meat (10-**30 grams**)
5) Fortified blended foods (40-**50 grams**)
6) Sugar (15-**25 grams**)
7) Iodized salt (**5 grams**)

The nutritional contribution of each type of commodity will be based on the maximal amount in grams the commodity contributes in rations based on the "acceptable basic rations" as described by the WFP. Thus, the score will evaluate the nutritional contribution of cereals at 450 grams, pulses at 100 grams, oil at 30 grams, fish and meat at 30 grams, fortified blended foods at 50 grams, sugar at 25 grams and iodized salt at 5 grams.

3.8 Mean MRM2: Ration Adjusted Minimal Requirements Met

In order to assess the impact of a system of commodities, as distributed in rations, the first step is to identify commodities based on whether they are classified as a cereal, pulse, oil, fish/meat, fortified blended food, sugar, or iodized salt. Next, instead of assessing the commodity's contribution to micronutrient, energy, fat and protein per 100 gram, the micronutrient, energy, fat and protein contribution is based on the upper limits of commodities in rations. The adjustment factors to convert from the value of the MRM1, based on 100 grams, to ration quantities, are presented in the formulas below.

MRM2 = MRM1 * ration adjustment coefficient
Ration adjustment coefficient = Upper limits of ration quantities/100 grams

1) Mean MRM2 for Cereals= 4.5 * mean MRM1
2) Mean MRM2 for Pulses= 1* mean MRM1
3) Mean MRM2 for Oil=0.5 * mean MRM1
4) Mean MRM2 for Fish and meat=0.3 * mean MRM1
5) Mean MRM2 for Fortified blended foods=0.5 * mean MRM1
6) Mean MRM2 for Sugar= 0.25 * mean MRM1
7) Mean MRM2 for Iodized salt= .05 * mean MRM1

3.9 Multiple Commodities MRM2

As with the mean MRM1 values, the mean MRM2 values across multiple commodities involves calculating a mean of means. This mean of mean MRM2s will be henceforth referred to as "Mean of Multiple Commodities MRM2." This value is the Mean MRM2 values averaged across the commodities included in the food aid package.

$$\text{Mean of Multiple Commodities MRM2} = \overline{\text{Multiple Commodities MRM2}}$$

$$\overline{\text{Multiple Commodities MRM2}} = \frac{\sum_{i=1}^{n} \overline{\text{MRM2}}}{n}$$

∑ denotes summation
n denotes the number of commodities
$X_1, X_2, \ldots X_n$ denote the individual nutrients X_1 being energy, X_2 being fat, $\ldots X_{10}$ being vitamin C.

3.10 Mean Minimal Requirements Met per year per ton (MRM3)

The next step in our calculations is to calculate the number of daily minimal requirements provided by one ton of commodity. MRM3 is equivalent to MRM1 values, but scaled to the units of food aid deliveries. While MRM1 scores are the minimal requirements met per day from 100 grams, food aid is calculated based on annual deliveries in metric tones. In this case, MRM4 values are used to score the metric tonnes of food aid delivered to and from Ethiopia and Sudan in 2006. Thus the MRM3 score converts the initial MRM1 score from 100 grams into 1 ton and from daily requirements into annual requirements. **Table 2** below shows the number of daily minimal requirements met per 100 gram (MRM1) of food aid for a selected number of commodities. **Table 3** shows the same results in metric tonnes, which are the same as the MRM1 values multiplied by 10,000. The change from 100 grams to a measure of tons given annually does not change the interpretation of commodity quality.

Table 2 Minimal requirements met (MRM1s) per 100 grams for selected commodities

commodity	MRM1 ENERGY	MRM1 PROTEIN	MRM1 FAT	MRM1 IRON	MRM1 IODINE	MRM1 VIT. A	MRM1 THIAMINE	MRM1 RIBOFLAVIN	MRM1 NIACIN	MRM1 VIT. C	MEAN MRM1 score
BEANS	0.16	0.45	0.02	0.20	<.01	<.01	0.56	0.14	0.55	0.18	0.23
CER & GRAINS	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17
CORN SOY BLD	0.18	0.33	0.17	0.43	0.38	0.03	0.59	0.34	0.52	1.43	0.44
EDIBLE FAT	0.41	<.01	2.45	<.01	<.01	1.20	<.01	<.01	<.01	<.01	0.41
FAFFA	0.19	0.28	0.18	0.20	<.01	<.01	0.11	0.29	0.42	1.07	0.27
H.R.W.WHT	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17
IODISED SALT	<.01	<.01	<.01	<.01	20.00	<.01	<.01	<.01	<.01	<.01	2.00
LENTILS	0.16	0.38	0.02	0.22	<.01	<.01	0.53	0.18	0.57	0.21	0.23

Table 3 Minimal requirements met (MRMs) per ton for selected commodities

commodity	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLAVIN	NIACIN	VIT. C	Sum micro-nutrients
BEANS	1586	4495	200	2000	0	40	5556	1429	5467	1786	22557
CER & GRAINS	1571	2343	375	976	0	0	3333	500	7433	0	16532
CORN SOY BLD	1790	3276	1725	4268	3793	345	5889	3429	5167	14286	43968
EDIBLE FAT	4105	0	24450	0	0	12000	0	0	0	0	40555
FAFFA	1914	2800	1750	1951	0	0	1111	2857	4167	10714	27265
H.R.W.WHT	1571	2343	375	976	0	0	3333	500	7433	0	16532
IODISED SALT	0	0	0	0	200000	0	0	0	0	0	200000
LENTILS	1619	3810	150	2195	0	0	5333	1786	5670	2143	22706

Table 3 shows results in tons per day whereas our data for food aid deliveries to Ethiopia and Sudan is given for the whole of 2006. The units are made equal by dividing the daily minimal requirements into a measure of minimal annual requirements, dividing by 365. The results of **Table 3** are thus further divided by 365 to create MRM3 values that convert MRM1 (daily requirements per 100 grams) into units appropriate for deliveries given over a year (2006) and in metric tonnes.

$$MRM3 = (MRM1 * 10,000) / 365$$

3.11 Weighted mean MRMs per tons per year (MRM4)

Some commodities represent only a small proportion of food aid, as little as under one percent of the total tons given, while other commodities may represent as much as half of the food aid given. Thus, a weighted average is most appropriate as it accounts for the relative contribution each commodity makes to total food aid deliveries. Here we describe the weighted average, which can be calculated per nutrient as well as applied to the total MRM3 score. The weighted averages (MRM4 scores) are based on the formula shown below. The resulting MRM4 scores provide the number of minimal requirements met for each nutrient per ton of food aid for a year.

$$\mathbf{MRM4 = \sum((MRM3C_{1\ to\ i})*(C_{tons1\ to\ i}/T_{tons}))}$$

$\sum$ denotes summation

$MRM3C_{1\ to\ i}$ is the MRM3 value of the individual commodities 1 to “i”, “i” being the total number of commodities.

$C_{tons\mathbf{1\ to\ i}}$ = the tons given of commodity 1 to “i”, “i” being the total number of commodities.

T_{tons}= the total tons of food aid given

3.12 Ratio of limiting and abundant nutrients

The MRM4 measures per nutrient can be used to assess how well the food aid deliveries provide requirements for all nutrients equally. A nutrient is "limiting" to the extent that it contributes less to the minimal requirements than other nutrients, and thereby has a lower MRM4 score. In theory, the number of minimal requirements is 'limited' by the nutrient with the lowest MRM4 score. If iodine, for example, has the lowest MRM4 value, the number of people whose nutritional needs are met is limited by iodine. The total number of persons whose complete nutritional needs are met for a year, per ton of food aid, cannot be higher than the MRM4 value of iodine. The concept of the "limiting nutrient", i.e. the nutrient with the lowest MRM4 value, helps in identifying how the food aid delivery could be improved. The concept of a ratio of the 'limiting nutrient' compared to the nutrient with the highest MRM4 score (the 'abundant nutrient') helps to assess the unequal distribution of the nutrients in foods. Furthermore, presenting the limiting and abundant nutrients together with the adjusted mean MRM4 score provides a picture of the food aid package.

3.13 Summarizing the data using minimal, mean and maximum MRM4

The above scores, MRM1, MRM2, and MRM4 provide a summary measure for assessing the quality of food aid deliveries, but each of these summary scores involves a loss of vital information. Namely, all of the measures are averages counting all nutrients equally. While the ratio of limiting and abundant nutrients can help to describe the degree of variation in the MRM4 results, it doesn't in itself provide a means of adapting the summary score. Thus, as a final step we will test 2 approaches for summarizing the components of the scores. The first option is to use the concepts above of the limiting and abundant nutrients to summarize the component MRM4 values of a food aid delivery. For example, a hypothetical food aid package per ton might meet the iodine needs of only one person for a year but might provides enough energy to meet the needs of 15 people per year. A summary score could express these together with the median MRM4 requirements. For example, a summary MRM4 result might be 5.3 minimal requirements met but the minimum, median and maximum MRM4 values may be 1, 4 and 15 and summarized in a data code as 01.04.15.

3.14 Summarizing the data based on clusters

It is not possible to separately provide the nutrient-scores, particularly if all 18 nutrients are included. Summarizing the data using minimum, mean and maximum MRM4 values provides a picture of the results. However, the nutrients represented by the minimal and maximum MRM4 values will differ in every analysis. Thus, a second approach is needed that allows for describing data for clusters of nutrients. Here we will identify nutrient clusters using principle component analysis using SAS 8.1 (Cary, NC). This analysis will help in determining which nutrient scores can be most logically combined with minimal loss of information. The number of components and nutrients included will be determined based on results from the principle component analysis. Once the nutrient clusters are identified, the nutrients that belong together in a cluster will be averaged and the mean value for the cluster presented in a data code ranging from 00 to 99. Imagine a result that identifies the 3 clusters as the macronutrients, one as vitamins, and the third as minerals. In such a scenario the first cluster would be an average of protein, energy and fat and the mean would be rounded to a whole number ranging from 00 to 99. A coded string 05.09.03 would indicate a mean MRM4 score for the macronutrients as 5, a mean for vitamins as 9 and a mean for the minerals together as 3. Such a code would be easy to interpret at a glance and would be consistent.

3.13 Data source: Food aid deliveries from Ethiopia and Sudan

The MRM1, MRM2, MRM3 and MRM4 values will be given for all food aid commodities given to Ethiopia and Sudan. We use the above methods to separately calculate the quality of food aid given and received by Ethiopia and Sudan, separately assessing the quality of food aid given by the United States and the European Commission countries to Ethiopia and Sudan. The total food aid given and received will be separately assessed using the Mean of Commodities MRM1, Mean of Commodities MRM3 and MRM4 measures. Finally, separately by recipient and donor, the food aid deliveries will also be assessed for the limiting nutrient relative to abundant nutrient, codes will be presented for the minimum, mean and maximum nutrient MRM4 values. As the last step, the coding system based on principle component analysis will be shown by recipient and donor. These results, following the methods above, will be used to compare the quality of food aid given and received by Ethiopia and Sudan, and the food aid given by the United States and the European Commission.

4. Results

4.1 Tons of food aid given and received: Ethiopia and Sudan

The tons of food aid given and received by Ethiopia and Sudan in 2006 are shown by commodity in **Table 4.** All commodities are presented, with the tons received or given rounded to the nearest ton. The table shows the commodities given to Ethiopia, Commodities received by Ethiopia amount to 661,729 tons of food aid provided in 22 commodities. United States contribution to Ethiopia is 427,701 tons of emergency food aid and the European Commission countries provide 92,943 tons of emergency food aid. **Table 4** shows that Sudan received 586,243 tons of emergency food aid, of which 478,816 came from the United States and 70,538 tons came from the European Commission.

4.2 Food aid quality by commodity

The results for MRM1 are assessed per 100 grams and MRM2 is assessed per ration quantity. These results per commodity are presented irrespective of donor and recipient. Instead, **Table 5** shows the nutritional values for all food aid commodities given or received by Ethiopia and Sudan. Results are assessed as minimal requirements met per 100 grams (MRM1), and the MRM1 adjusted by ration quantities (MRM2). The food commodities with the highest scores per 100 grams are fortified or fortified blended foods, such as corn soy blend and iodized salt. Of the non fortified foods the highest MRM1 score was for nuts and ground nuts, providing an average of 0.44 requirements met per 100 grams. A number of the highest scoring commodities have individual nutrients that contribute disproportionately to the high score. These high scoring nutrients can be seen from the nutrient MRM1 values greater than 1. For example, one hundred grams of iodized salt provides 2 minimal daily requirements but all of the MRMs come from a single nutrient, iodine, which contributes 20 MRMs to the total. Adjusting for ration quantities, shown in the MRM2 column, reduces the score for iodized salt from 2.0 to 0.10 of the minimal requirements.

Table 4. Food Aid Deliveries in Tons to Ethiopia and Sudan (2006)

	Ethiopia			Sudan		
TOTAL	Total Aid Given	Given by European Commission	Given by USA	Total Aid Given	Given by European Commission	Given by USA
BEANS	3,111			4,290	3,300	
BISCUITS				1		
CER & GRAINS	170					
CORN SOY BLD	56,208		45,558	23,610	6,540	12,214
DRY WHOLE MILK				5		
EDIBLE FAT	15	15				
FAFFA	22,189	5,479				
GROUND NUTS				3,049	536	
H.R.W.WHT	41,995		41,995			
IODISED SALT	150			6,452	6,312	80
LENTILS	23,949		23,749	31,038	1,685	29,328
MAIZE	109,630	40,700	2,417	10		
MILK				<1		
NUTS				35		
PEAS	2,650		2,650			
RICE	5,460		5,460			
SALT				561		
SOFT WHEAT	17,450		17,450			
SORGHUM	1,088			320,073	30,161	284,130
SOYA FLOUR	788	788				
SOYA OIL	45			28		
SUGAR	138			18,685	14,352	326
VEG OIL	13,945		11,159	24,303	6,842	15,747
WHEAT	347,610	45,961	268,349	151.691		136.990
WHEAT FLOUR	2,693					
WHE SOYA BLD	3,496		3,495			
WHOLE PEAS	1,130		1,130			
YEL SPL PEAS	7,821		4,286	2.110,20	810	
TOTAL TONS	**661,729**	**92,943**	**427,701**	**586,243**	**70,538**	**478,816**

4.3 Limiting the contribution of individual nutrients to MRM1 & MRM2

Another method for adjustment is to limit individual nutrients to contributing a maximum MRM1 of 1.0. **Table 6** shows the commodities with nutrients having nutrient MRM1 values greater than 1. These commodities include blended foods, iodized salt, oil and nuts. Capping the nutrient contribution to the commodity's mean MRM1 most significantly reduces the mean MRM1 score for iodized salt. The result of capping the score at MRM1 is the same as the MRM2 adjustment, both methods result in a score of 0.10. While capping the nutrient MRM1 contribution lowers the mean MRM1 score, the effect is less than MRM2 ration adjustment. For example, corn soy blend has an MRM1 score of 1.43 minimal requirements for vitamin C. Capping the contribution at 1, results in a slight reduction of the MRM1 score, from 0.44 to 0.41. Adjusting the MRM1 score by applying the ration limit of blended foods halves the score to .22 as shown by the MRM2 score in **Table 5.**

4.4 Quality of commodities per 100 grams (MRM1 & MRM2)

Table 7 shows the total MRM1 values for all commodities given and received. The quality of the food given to Ethiopia compares well to the quality of food aid given to Sudan. However, the quality of the EC and USA contributions is both higher for Sudan than for Ethiopia. This difference can be explained by the EC and USA contributions of iodized salt. The results for the ration adjusted MRM2 values show a reversal of the pattern. The MRM2 values increase for Ethiopia reflecting a relatively higher proportion of grains, the nutritive values of which are multiplied by 4.5 in the MRM2 scores. In contrast, the MRM2 values to Sudan include high nutritive quality food commodities such as blended foods and iodized salt that are high in nutrients per 100 grams, but which are distributed in smaller quantities.

Table 5. MRM1 & MRM2: Minimal requirements met per 100 grams

	MRM1 Values: Minimal Requirements Met per 100 g										MRM1	MRM2
COMM-ODITY	EN-ERGY	PRO TEIN	FAT	IRON	IO-DINE	VIT. A	THI AMI NE	RIB OFL AVI N	NIA CIN	VIT. C	Mean MRM1	MRM1 limited to ration quantities
BEANS	0.16	0.45	0.02	0.20	<.01	<.01	0.56	0.14	0.55	0.18	0.23	0.23
BISCUITS	0.21	0.23	0.38	0.27	0.50	0.50	0.56	0.50	0.50	0.71	0.44	-
CER & GRAINS	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17	0.74
CORN SOY BLD	0.18	0.33	0.17	0.43	0.38	0.03	0.59	0.34	0.52	1.43	0.44	0.22
DRY WHO MILK	0.24	0.48	0.68	0.01	<.01	0.56	0.31	0.86	0.57	<.01	0.37	0.19
EDIBLE FAT	0.41	<.01	2.45	<.01	<.01	1.20	<.01	<.01	<.01	<.01	0.41	0.12
FAFFA	0.19	0.28	0.18	0.20	<.01	<.01	0.11	0.29	0.42	1.07	0.27	0.14
GROUND NUTS	0.27	0.49	1.23	0.11	0.13	<.01	0.71	0.10	1.35	<.01	0.44	-
H.R.W.WHT	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17	0.74
IODISED SALT	<.01	<.01	<.01	<.01	20.0	<.01	<.01	<.01	<.01	<.01	2.00	0.10
LENTILS	0.16	0.38	0.02	0.22	<.01	<.01	0.53	0.18	0.57	0.21	0.23	0.23
MAIZE	0.17	0.19	0.10	0.12	<.01	0.28	0.43	0.14	0.18	<.01	0.16	0.73
MILK	0.03	0.06	0.10	<.01	0.10	0.11	0.03	0.12	0.07	0.04	0.07	0.07
NUTS	0.27	0.49	1.23	0.11	0.13	<.01	0.71	0.10	1.35	<.01	0.44	-
PEAS	0.16	0.47	0.03	0.11	<.01	0.09	0.78	0.14	0.24	0.06	0.21	0.21
RICE	0.17	0.14	0.02	0.02	<.01	<.01	0.08	0.04	0.13	<.01	0.06	0.27
SALT	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SOFT WHEAT	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17	0.74
SORGHUM	0.16	0.21	0.08	0.11	<.01	<.01	0.38	0.11	0.42	<.01	0.15	0.04
SOYA FLOUR	0.23	0.70	0.59	0.17	<.01	0.01	0.83	0.20	0.17	<.01	0.29	0.29
SOYA OIL	0.42	<.01	2.47	<.01	<.01	<.01	<.01	<.01	<.01	<.01	0.29	0.07
SUGAR	0.19	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	0.02	0.01
VEG OIL	0.42	<.01	2.50	<.01	0.07	<.01	<.01	<.01	<.01	<.01	0.30	1.35
WHEAT	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17	0.74
WHEAT FLOUR	0.16	0.23	0.04	0.10	<.01	<.01	0.33	0.05	0.74	<.01	0.17	0.74
WHE SOYA BLD	0.18	0.38	0.15	0.51	<.01	1.00	1.67	0.43	0.76	1.43	0.65	0.32
WHOLE PEAS	0.16	0.47	0.03	0.11	<.01	0.09	0.78	0.14	0.24	0.06	0.21	0.21
YEL SPL PEAS	0.16	0.47	0.03	0.11	<.01	0.09	0.78	0.14	0.24	0.06	0.21	0.10

Table 6. Capping the contribution of nutrients to MRM1 & MRM2

COMM-ODITY	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLAVIN	NIACIN	VIT. C	MRM1	MRM2
CORN SOY BLD	0.18	0.33	0.17	0.43	0.38	0.03	0.59	0.34	0.52	**1.00**	0.40	0.20
EDIBLE FAT	0.41	<.01	**1.00**	<.01	<.01	**1.00**	<.01	<.01	<.01	<.01	0.24	0.07
FAFFA	0.19	0.28	0.18	0.20	<.01	<.01	0.11	0.29	0.42	**1.00**	0.27	0.13
GROUND NUTS	0.27	0.49	**1.00**	0.11	0.13	<.01	0.71	0.10	**1.00**	<.01	0.38	
IODISED SALT	<.01	<.01	<.01	<.01	**1.00**	<.01	<.01	<.01	<.01	<.01	0.10	0.01
NUTS	0.27	0.49	**1.00**	0.11	0.13	<.01	0.71	0.10	**1.00**	<.01	0.38	
SOYA OIL	0.42	<.01	**1.00**	<.01	<.01	<.01	<.01	<.01	<.01	<.01	0.14	0.04
VEG OIL	0.42	<.01	**1.00**	<.01	0.07	<.01	<.01	<.01	<.01	<.01	0.15	0.04
WHE SOYA BLD	0.18	0.38	0.15	0.51	<.01	1.00	**1.00**	0.43	0.76	**1.0**	0.49	0.25

Table 7. Mean MRM1 of Food Aid Deliveries

	ETHIOPIA			SUDAN		
	TOTAL	FROM EUROPEAN COMISSION COUNTRIES	FROM THE USA	TOTAL	FROM EUROPEAN COMISSION COUNTRIES	FROM THE USA
BEANS	0.23			0.23	0.23	
BISCUITS				0.44		
CER & GRAINS	0.17					
CORN SOY BLD	0.44		0.44	0.44	0.44	0.44
DRY WHO MILK				0.37		
EDIBLE FAT	0.41	0.41				
FAFFA	0.27	0.27				
GROUND NUTS				0.44	0.44	
H.R.W.WHT	0.17		0.17			
IODISED SALT	2.00			2.0	2.00	2.00
LENTILS	0.23		0.23	0.23	0.23	0.23
MAIZE	0.16	0.16	0.16	0.16		
MILK				0.07		
NUTS				0.44		
PEAS	0.21		0.21			
RICE	0.06		0.06			
SALT				0		
SOFT WHEAT	0.17		0.17			
SORGHUM	0.15			0.15	0.15	0.15
SOYA FLOUR	0.29	0.29				
SOYA OIL	0.29			0.29		
SUGAR	0.02			0.02	0.02	0.02
VEG OIL	0.30		0.30	0.30	0.30	0.30
WHEAT	0.17	0.17	0.17	0.17		0.17
WHEAT FLOUR	0.17					
WHE SOYA BLD	0.65		0.65			
WHOLE PEAS	0.21		0.21			
YEL SPL PEAS	0.21		0.21	0.21	0.21	
MEAN COMMODITY MRM1	0.32	0.26	0.25	0.35	0.44	0.47
MEAN COMMODITY MRM2	*0.36*	*0.40*	*0.38*	*0.27*	*0.22*	*0.21*

4.5 Quality of commodities per ton (MRM3)

Table 8 shows the results of all commodities given to Ethiopia and Sudan in terms of the average requirements met per ton of commodity over the course of a year. One ton of iodized salt provides enough to meet the iodine needs of nearly 548 individuals for a year. Averaging over 10 nutrients, iodized salt provides on average 54.8 requirements a day for a year. The mean MRM3 score of fortified foods is more than 11 requirements per ton per day for a year. Amongst the non-fortified foods, the commodities with the greatest MRM3 values are nuts (MRM3=12.05) and vegetable oil (MRM3=8.21).

4.6 Calculations for adjusted MRM3 (MRM4)

Table 9 shows the calculations (MRM4) scores for the food aid deliveries to Ethiopia in order to demonstrate how these calculations were done. The weighting co-efficient for each commodity, shown in column 1, was applied to the MRM3 values of **Table 8** to calculate the nutritional contribution made by each commodity per ton of food aid given**.** Because some food commodities make up a small proportion of the total food aid given, some weighting coefficients are less than 0.01. These are shown in the first column only as <0.01 although actual values were used in calculations. Beans, for example, make up less than 1% of the total food aid package to Ethiopia. Even so, in a ton of food aid, beans contribute 0.02 minimal requirements of energy, riboflavin and vitamin C, 0.06 minimal requirements of energy, 0.07 minimal requirements of thiamin and niacin. The average of these contributions is shown in the final column, with beans contributing, on average, 0.03 minimal requirements per ton of food aid. The weighting of the nutritional contributions, however, is best shown by wheat. Wheat constitutes 53% of the food aid deliveries to Ethiopia, thus by definition wheat contributes to 53% of the total MRM4 score (2.38 out of the total 5.38).

Table 8. MRM3: Mean MRMs Per Ton Per Day

commodity	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLAVIN	NIACIN	VIT. C	MEAN MRM3
BEANS	4.34	12.32	0.55	5.48	<.01	0.11	15.22	3.91	14.98	4.89	6.18
BISCUITS	5.87	6.26	10.27	7.35	13.70	13.70	15.22	13.70	13.70	19.57	11.93
CER & GRAINS	4.31	6.42	1.03	2.67	<.01	<.01	9.13	1.37	20.37	<.01	4.53
CORN SOY BLD	4.91	8.98	4.73	11.69	10.39	0.94	16.13	9.39	14.16	39.14	12.05
DRY WHO MILK	6.52	13.05	18.49	0.33	<.01	15.34	8.52	23.68	15.59	<.01	10.15
EDIBLE FAT	11.25	<.01	66.99	<.01	<.01	32.88	<.01	<.01	<.01	<.01	11.11
FAFFA	5.24	7.67	4.79	5.35	<.01	<.01	3.04	7.83	11.42	29.35	7.47
GROUND NUTS	7.40	13.46	33.70	3.06	3.65	<.01	19.48	2.64	37.05	<.01	12.05
H.R.W.WHT	4.31	6.42	1.03	2.67	<.01	<.01	9.13	1.37	20.37	<.01	4.53
IODISED SALT	<.01	<.01	<.01	<.01	547.95	<.01	<.01	<.01	<.01	<.01	54.79
LENTILS	4.44	10.44	0.41	6.01	<.01	<.01	14.61	4.89	15.53	5.87	6.22
MAIZE	4.57	5.22	2.74	3.27	<.01	7.73	11.72	3.93	5.02	<.01	4.42
MILK	0.86	1.67	2.67	0.04	2.74	3.04	0.91	3.33	1.83	0.98	1.81
NUTS	7.40	13.46	33.70	3.06	3.65	<.01	19.48	2.64	37.05	<.01	12.05
OILS & FATS	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
PEAS	4.45	12.84	0.82	2.94	<.01	2.45	21.31	3.91	6.62	1.76	5.71
RICE	4.76	3.71	0.48	0.53	<.01	<.01	2.13	0.98	3.65	<.01	1.62
SALT	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SOFT WHEAT	4.31	6.42	1.03	2.67	<.01	<.01	9.13	1.37	20.37	<.01	4.53
SORGHUM	4.37	5.74	2.05	3.01	<.01	<.01	10.35	2.94	11.41	<.01	3.99
SOYA FLOUR	6.18	19.20	16.10	4.61	<.01	0.33	22.83	5.48	4.57	<.01	7.93
SOYA OIL	11.61	<.01	67.74	<.01	<.01	<.01	<.01	<.01	<.01	<.01	7.94
SUGAR	5.22	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	0.52
VEG OIL	11.61	<.01	68.49	<.01	2.01	<.01	<.01	<.01	<.01	<.01	8.21
WHEAT	4.31	6.42	1.03	2.67	<.01	<.01	9.13	1.37	20.37	<.01	4.53
WHEAT FLOUR	4.31	6.42	1.03	2.67	<.01	<.01	9.13	1.37	20.37	<.01	4.53
WHE SOYA BLD	4.83	10.44	4.11	13.90	<.01	27.29	45.66	11.74	20.78	39.14	17.79
WHOLE PEAS	4.45	12.84	0.82	2.94	<.01	2.50	21.31	3.91	6.62	1.76	5.72
YEL SPL PEAS	4.45	12.84	0.82	2.94	<.01	2.50	21.31	3.91	6.62	1.76	5.72

Table 9. MRM4: Adjusted Mean MRMs Per Ton Per Day

COMM-ODITY	CTONS/TTONS	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLAVIN	NIACIN	VIT. C	CONTRIBUTION TO MRM4
BEANS	<0.01	0.02	0.06	<.01	0.03	<.01	<.01	0.07	0.02	0.07	0.02	0.03
CER & GRAINS	<0.01	<.01	<.01	<0.01	<.01	<.01	<.01	<.01	<.01	0.01	<.01	<.01
CORN SOY BLD	0.08	0.42	0.76	0.40	0.99	0.88	0.08	1.37	0.80	1.20	3.32	1.02
EDIBLE FAT	<0.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
FAFFA	0.03	0.18	0.26	0.16	0.18	<.01	<.01	0.10	0.26	0.38	0.98	0.25
H.R.W.WHT	0.06	0.27	0.41	0.07	0.17	<.01	<.01	0.58	0.09	1.29	<.01	0.29
IODISED SALT	<0.01	<.01	<.01	<.01	<.01	0.12	<.01	<.01	<.01	<.01	<.01	0.01
LENTILS	0.04	0.16	0.38	0.01	0.22	<.01	<.01	0.53	0.18	0.56	0.21	0.23
MAIZE	0.17	0.76	0.86	0.45	0.54	<.01	1.28	1.94	0.65	0.83	<.01	0.73
PEAS	<0.01	0.02	0.05	<.01	0.01	<.01	0.01	0.09	0.02	0.03	0.01	0.02
RICE	0.01	0.04	0.03	<.01	<.01	<.01	<.01	0.02	0.01	0.03	<.01	0.01
SOFT WHEAT	0.03	0.11	0.17	0.03	0.07	<.01	<.01	0.24	0.04	0.54	<.01	0.12
SORGHUM	<0.01	0.01	0.01	<.01	<.01	<.01	<.01	0.02	<.01	0.02	<.01	0.01
SOYA FLOUR	<0.01	0.01	0.02	0.02	0.01	<.01	<.01	0.03	0.01	0.01	<.01	0.01
SOYA OIL	<0.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SUGAR	<0.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
VEG OIL	0.02	0.24	<.01	1.44	<.01	0.04	<.01	<.01	<.01	<.01	<.01	0.17
WHEAT	0.53	2.26	3.37	0.54	1.40	<.01	<.01	4.80	0.72	10.70	<.01	2.38
WHEAT FLOUR	<0.01	0.02	0.03	<.01	0.01	<.01	<.01	0.04	0.01	0.08	<.01	0.02
WHE SOYA BLD	0.01	0.03	0.06	0.02	0.07	<.01	0.14	0.24	0.06	0.11	0.21	0.09
WHOLE PEAS	<0.01	0.01	0.02	<.01	0.01	<.01	<.01	0.04	0.01	0.01	<.01	0.01
YEL SPL PEAS	0.01	0.05	0.15	0.01	0.03	<.01	0.03	0.25	0.05	0.08	0.02	0.07
MRM4		4.60	6.64	3.18	3.75	1.05	1.55	10.35	2.91	15.95	4.78	5.48

4.7 Quality per ton adjusted by commodity weight (MRM4)

Table 10 shows all of the MRM4 values for food aid deliveries to Ethiopia and Sudan. The first column results are the same as shown in **Table 9** but are repeated here for comparison. Food aid given to Ethiopia, in total, from European Commission Countries (EC) and from the United States of America (USA) is shown in the first three columns. These results show that, per ton of food aid given, the energy needs could theoretically be met for between 4.49 to 4.60 individuals. This result is quite similar to that of Sudan, with a ton of food aid providing the energy requirements to feed 4.67 individuals for a year, the respective energy contributions from the EC food aid is slightly higher (potentially 4.93 daily energy requirements met) than from the USA (4.61 daily energy requirements met). The number of protein requirements met is even higher, except for the food aid deliveries from the EC to Sudan. Overall, energy and protein requirements MRM4 scores are quite similar for energy and protein both by recipient and donor countries. The greatest variability between the packages is shown in the food aid contributions to iodine from EC countries. The EC contribution to Ethiopia delivers less than 0.01 minimal requirements per ton of aid whereas the EC contribution to Sudan delivers as much as 50.22 minimal requirements met per ton of aid.

4.8 Limiting and abundant nutrients (MRM4)

The number of individuals who can be fed by aid deliveries is limited by the distribution of the nutrients in the food aid package. The values of these nutrients are highlighted in **Table 10.** For example, the lowest MRM4 value for Ethiopia's total food aid deliveries is for iodine (MRM4=1.05). Thus, only 1.05 individuals can have all their nutritional requirements met per ton of food aid given to Ethiopia. The ratio of iodine, as the limiting nutrient, over niacin, the most abundant nutrient, is 0.10. The small amount of iodine in the food aid delivered from the EC to Ethiopia produces and even smaller ration of the limiting divided by abundant nutrient, with the result being less than <.01. Food aid to Ethiopia from the US is limited by vitamin A, which is only .02 of the niacin contribution. Vitamin A is the limiting nutrient for all deliveries to and from Sudan, but the ratio is slightly higher than it was for Ethiopia at 0.15. The ratios of food aid delivered to Sudan from EC countries and from the USA are both less than 0.01, relating to the low amounts of vitamin A.

4.9 Summarizing the data using minimal, mean and maximum MRM4

The information from **Table 10** can be used to construct summary codes. Presenting only the mean MRM4 loses the information about individual nutrients. For example, the mean MRM4 ranges from the USA contribution to Sudan, which provides an average of 4.63 requirements met per ton of food aid, to the EC contribution to Sudan which provides 9.22 requirements per ton of food aid. However, both of these values are limited by a small amount of vitamin A requirements met. Vitamin A requirements in the package from the US to Sudan are as low as 0.02 requirements met. Likewise, the EC package, which has a mean MRM4 of twice that of the US, only provides 0.12 vitamin A requirements per ton of food aid. Rounding the values to whole numbers would provide codes ranging from 0 to 50 for individual nutrients. All numbers lower than 0.5 are reported as 00. The quality of each food package can be summarized presenting the lowest value, mean, and highest value for MRM4. The numbers will be followed by abbreviations to indicate the identity of the limiting and abundant nutrient, such as "I" for iodine, "A" for vitamin A, and "B3" for niacin. For example, where the limiting nutrient is iodine and abundant nutrient is niacin, this will be indicated as "I_B3".

Ethiopia total food aid deliveries: 01.05.16 / I_B3
From EC countries To Ethiopia: 00.05.13 / I_B3
From USA to Ethiopia: 00.06.18 / A_B3
Sudan total food aid deliveries: 00.05.13 / A_B3
From EC countries to Sudan: 00.09.50 / A_I
From USA to Sudan: 00.05.14 / A_B3

Table 10. MRM4 values for food aid deliveries to Ethiopia and Sudan

RECIPIENT & DONOR	EN-ERGY	PRO-TEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLAVIN	NIA-CIN	VIT. C	Mean MRM4	Lowest MRM4/ Highest MRM4
ETHIOPIA TOTAL	4.60	6.64	3.18	3.75	1.05	1.55	10.35	2.91	15.95	4.78	5.48	0.10
FROM EC	4.49	6.07	2.14	3.11	<0.01	3.39	10.02	2.91	12.98	1.73	4.68	<<.01
FROM USA	4.58	6.86	3.17	3.82	1.16	0.41	10.40	2.53	18.35	4.85	5.61	0.02
SUDAN TOTAL	4.67	5.92	4.63	3.19	6.55	0.05	9.73	2.65	13.23	1.93	5.26	0.15
FROM EC	4.93	4.36	8.26	2.83	50.22	0.12	7.38	2.49	7.62	4.02	9.22	<<.01
FROM USA	4.61	6.11	3.91	3.22	0.42	0.02	10.06	2.67	13.91	1.36	4.63	<<.01

4.9 Summarizing the data based on clusters

The principle components analysis was done to explore the possibility of clustering nutrients together in foods. The scree plot of the first showed a cluster of nutrients hovering near 1 (see Appendix). Setting the eigenvalue at the standard value of 1 resulted in three principle components. In this first example, vitamin C appeared in multiple (two) factors and therefore was excluded. After excluding Vitamin C, the three clusters of nutrients are shown as Factors 1, 2 and 3 in **Table 11**. While there was no clear gap in the eigenvalues, the next cutoff eigenvalue was near to one (0.96) allowing for inclusion of a fourth factor. Resetting the eigenvalue shows a different pattern of clustering. In the second analysis, vitamin A appears in multiple clusters but and was excluded but vitamin C appeared in only one cluster, and was therefore retained. The four factors are shown in **Table 12**.

Table 11. Principle components of three factors: Excluding vitamin C

Factor 1	Factor 2	Factor 3
Thiamine	Energy	Protein
Riboflavin	Fat	Iodine
Niacin	Vitamin A	
Iron		

Table 12. Principle components of four factors: Excluding vitamin A

Factor 1	Factor 2	Factor 3	Factor 4
Thiamine	Energy	Niacin	Protein
Riboflavin	Fat	Iodine	
Iron			
Vitamin C			

In order to retain as much information as possible, I have chosen to use as an example the results of the four factors. This construction provides the quality of food aid in terms of energy and fat (factor 2) separately from protein (factor 4) and splits the remaining nutrients into two parts. Below the MRM4 values of the nutrients in each component are averaged, such that Factor 1 represents the average MRM4 value of Thiamine, Riboflavin, Iron and Vitamin C, and Factor 4 represents only the MRM4 value for protein. The codes are represented as the mean of each factor, rounded to whole numbers and with two place holders. Each factor is separated by a decimal. The mean MRM4 value for thiamine, riboflavin, iron and vitamin C is 4.45 (rounded to 5), the mean MRM4 value for energy and fat was 5.62 (rounded to 6) the mean MRM4 for niacin and iodine was 8.50 and the MRM4 value for protein was 6.54, these values were rounded to 5, 6, 9, and 7, yielding the code 05.06.09.07. All 'coded' results using the four factors are shown below for illustrative purposes.

Ethiopia total food aid deliveries: 05.06.09.07
From EC countries To Ethiopia: 04.05.06.06
From USA to Ethiopia: 05.06.10.07
Sudan total food aid deliveries: 04.05.10.06
From EC countries to Sudan: 04.05.28.04
From USA to Sudan: 04.05.07.06

5. Discussion

5.1 Limitations of existing food composition tables

These results illustrate key limitations to creating a summary score for food quality using nutritive values. The main aim of this report was to assess the nutritive value of food aid focusing on the priority nutrients identified in World Food Programme publications. Fifteen nutrients were identified by the World Food Programme as important to the emergency food aid context. Unfortunately, no single appropriate food composition table includes all 15 nutrients and reflects the composition of foods included here. In order to maintain the quality of analysis, and consistency of results, we have used food composition tables from Nutval. To the extent that these results do not include 8 of the nutrients identified by the World Food Programme as important to the emergency food aid context, these results do not present a full picture of food quality in relation to nutritional needs. Furthermore, even including all priority nutrients, additional essential vitamins and trace minerals are also missing. While it would be impractical to comprehensively include all essential nutrients in a score for food aid quality, the exclusion of essential nutrients will remain a limitation of the score measure. Optimally, this analysis would be done combining data from food composition tables or with an updated version of Nutval.

5.2 Limitations of the analysis

All of the measures shown above involve a loss of information, all scores are simply averaging across multiple micronutrients to provide a mean score per commodity. Additional information is lost in further averaging the mean MRM1 scores across multiple commodities. The ration adjusted MRM2 provides a score based on the upper limit for how much a given commodity can contribute can contribute to an individual's daily requirements. The differential contribution of different commodities is addressed in the final score, the MRM4 as measure of nutrient requirements provided per ton of food aid. MRM4 is adjusted for the actual amount provided in the food aid. The loss of information in all scores is partly addressed by presenting components of the score.

5.3 MRM1 and MRM2: Assessing food quality in grams

There are critical limitations of the MRM1 and MRM2 scores. Both scores based on the contribution of foods either per 100 grams (MRM1) or based on actual ration quantities (MRM2). While the MRM1 score is helpful in identifying the nutritive value of food commodities at the individual level, results are skewed by the high concentration of micronutrients in fortified foods. Capping the MRM1 results by setting limits per nutrient help to address the disproportionate influence of specific nutrients. However, the resulting quality score does fully not capture the nutritional benefit that supplemented foods contribute to food aid. While the MRM2 also partially addresses the issue of addressing the disproportionate contribution of single nutrients to a food commodity score, using the limits provided in rations, these results remain difficult to interpret. The main distinctions between the two values is that the first shows the minimal requirements met in a set 100 gram quantity while the other shows the minimal requirements met based on the ration amounts provided. The first score provides the advantage of comparability across commodities, as the weights are equal. The second provides the advantage of assessing the quality of commodities as provided in food aid.

5.4 MRM3 and MRM4: Assessing food quality per ton

The interpretation of MRM3 shares in the limitations of MRM1, in that there is no capping of excessive nutrients. Capping MRM3 would be inappropriate as it would distort the MRM4 results. For example, if the iodine contribution to MRM3 was limited, it would take away from the contribution iodized salt contributes to the final adjusted score. The MRM4 provides a measure for assessing multiple commodities together, with outcomes assessed by single nutrients or for an average of multiple nutrients. Hypothetically, the MRM4 score could be used to indicate the number of individuals whose needs are completely met. However, the hypothetical scenario would require that all nutrient scores were distributed evenly in foods, that all foods distributed evenly to the population, and that all individuals had the same energy and nutrient needs as the reference individual used as the basis for setting the ‘minimal requirements’ cutoffs. Unfortunately, results here show that even the first assumption cannot be met. Nutrients are not evenly distributed in foods. The ratio of the lowest and highest MRM4 scores ranging from less than 0.01 to 0.15. At worst, in this analysis the limiting nutrient is present in amounts that are one-hundredth that of the most abundant nutrient and at best it is less than one-sixth of the most abundant nutrient.

5.5 A compartmentalized score: Minimum, mean and maximum MRM4

The optimal approach for assessing food quality would not only average the results across several nutrients, but would also show the results from individual nutrients. Two main approaches were presented here. The first was based on a code that strings together MRM4 results, providing the number from the lowest MRM4 score, the mean MRM4 and highest MRM4 score. These numbers, together with abbreviations for the limiting and abundant nutrients, provides a picture of what is most needed to improve the nutritional quality of a food aid package and the limits of how many people whose requirements could be met. However, the limiting and abundant nutrients differ for every set of commodities and thus the results are hard to compare. The second approach, averaging clusters of nutrients together and presenting the mean of each cluster, has the advantage of consistency. Using this method, food aid deliveries can be compared across multiple recipients and donors. Unfortunately, the disadvantage to a clustering of multiple components together is that, once again, information is lost in the process of taking a mean of multiple nutrient values. For example, in these results one of the clusters includes both iodine and niacin. The total food aid delivered to Ethiopia shows iodine as the limiting nutrient whereas niacin is most abundant, such that the averaged does not reflect a value that represents the score for either of the component nutrients. Information is lost in the process of clustering these two nutrients together.

5.5 A compartmentalized score: Alternative approaches

The above measures focus on a purely numerical process for constructing a coding system. Another approach, which may be more useful, would be to cluster together nutrients based on their relevance to the emergency food aid context. In the past, food aid was assessed in terms of energy requirements met. The MRM4 value for energy requirements provides an equivalent measure, but showing only the MRM4 for energy would not provide a new approach. The mean MRM4 shows a single measure that evaluates food aid quality over multiple nutrients. If this were presented together with the component results of the most important 3-4 nutrients, it would help to present a complete picture. A decision could be made based on a review of the literature to identify the 3 or 4 nutrients that contribute most to the short and long term health of populations served by emergency food aid.

5.6 Maximizing the number whose complete nutritional needs can be met

A final approach for assessing food aid could be based on the value of the limiting nutrient. This value is not only the theoretical, but the actual limit to how many individuals can have their complete annual nutritional needs per ton of food aid. The "limiting nutrient", or the lowest MRM4 score, represents the maximal number of individuals whose complete requirements can be met by the food package. These results indicate that food aid deliveries are most limited by vitamin A and, for Ethiopia, iodine. Increasing the relative quantities of Vitamin A and iodine fortified commodities would help to bridge the gap and could significantly improve the balance of nutrients in the food aid given and received.

6. References

Lachance PA, Fisher MC. Educational and technological innovations required to enhance the selection of desirable nutrients. Clin Nutr 1986;5:257-67.

Drewnowski A. Concept of a nutritious food: toward a nutrient density score. Am J Clin Nutr 2005;82:721-32.

FAO/WHO. Preparation and use of food based dietary guideliness. Report of a joint FAO/WHO consultation, Nicosia, Cyprus, 1996.

Hansen RG, Wyse BW, Sorenson AW. Nutrition quality index of food. Westport, CT: AVI publishing Co, 1979.

Institute of Medicine, Subcommittee on Technical Specifications for a High-Energy Emergency Relief Ration, Committee on Military Nutrition Research. High- energy nutrient dense emergency relief food product. Washington, DC: National Academy Press, 2002.

Kant, AK. Indexes of Overall Diet Quality: A review. J Am Diet Assoc. 2001: 85, 219-225.

Madden JP, Yoder MD. Program evaluation: food stamps and commodity distribution in rural areas of central Pennsylvania. Penn Agr Exp Sta Bull 1972:78;1-119.

Mercer N, Orringer C. Grocery shopping guide, Ann Arbor, MI: University of Michigan, 1988.

Snelling AM, Korba C, Burkey A. The national school lunch and competitive food offerings and purchasing behaviors of high school students. J Sch Health. 2007 Dec;77(10):701-5

World Health Organization and Food and Agriculture Organization of the United Nations. Vitamin and Mineral requirements in human nutrition, second edition. 2004.

Joint publication of United Nations High Commissioner for Refugees, United Nations Children Fund, World Food Programme and the World Health Organization. Food and Nutrition Needs in Emergencies, Geneva, Switzerland. World Health Organization. 2002

World Health Organization, the World Food Programme and the United Nations Children Fund. Preventing and controlling micronutrient deficiencies in populations affected by an emergency: Multiple vitamin and mineral supplements for pregnant and lactating women, and for children aged 6 to 59 months. Joint statement by the World Health Organization, the World Food Programme and the United Nations Children Fund.

7. Appendix: Principle Components Analysis Results

The FACTOR Procedure
Initial Factor Method: Principal Components

Prior Communality Estimates: ONE

Eigenvalues of the Correlation Matrix: Total = 10 Average = 1

	Eigenvalue	Difference	Proportion	Cumulative
1	2.48547603	0.62224222	0.2485	0.2485
2	1.86323382	0.68819321	0.1863	0.4349
3	1.17504061	0.20439832	0.1175	0.5524
4	0.97064229	0.02991742	0.0971	0.6494
5	0.94072487	0.09638427	0.0941	0.7435
6	0.84434060	0.16519391	0.0844	0.8279
7	0.67914670	0.18421383	0.0679	0.8959
8	0.49493287	0.19959585	0.0495	0.9454
9	0.29533702	0.04421183	0.0295	0.9749
10	0.25112519		0.0251	1.0000

3 factors will be retained by the MINEIGEN criterion.

The SAS System   12:15 Sunday, July 6, 2008 54

The FACTOR Procedure
Initial Factor Method: Principal Components

```
Scree Plot of Eigenvalues
      ,
      ,
      ,
      ,
      ,
  2.5 ˆ               1
      ,
      ,
      ,
      ,
      ,
      ,
  2.0 ˆ
      ,
      ,                       2
      ,
      ,
E     ,
i     ,
g 1.5 ˆ
e     ,
n     ,
v     ,
a     ,
l     ,                               3
u     ,
e 1.0 ˆ                                       4
s     ,                                               5
      ,                                                       6
      ,
      ,                                                               7
      ,
      ,
  0.5 ˆ                                                                       8
      ,
      ,
      ,                                                                               9       0
      ,
      ,
      ,
  0.0 ˆ
      ,
      ,
      ,
      ,
      Šƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒ
              0       1       2       3       4       5       6       7       8       9      10

                                                   Number
```

The FACTOR Procedure
Initial Factor Method: Principal Components

Factor Pattern

		Factor1	Factor2	Factor3
ENERGY	ENERGY	15	81 *	28
PROTEIN	PROTEIN	9	-12	43 *
FAT	FAT	-13	72 *	26
THIAMINE	THIAMINE	74 *	-14	18
RIBOFLVIN	RIBOFLVIN	79 *	-7	3
NIACIN	NIACIN	37	-41 *	25
IRON	IRON	82 *	-10	3
VIT__A	VIT# A	38	64 *	-31
VIT__C	VIT# C	53 *	20	-56 *
IODINE	IODINE	-15	-13	-58 *

Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3
2.4854760	1.8632338	1.1750406

Final Communality Estimates: Total = 5.523750

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.76750112	0.20765039	0.59873250	0.60494499	0.62260184

NIACIN	IRON	VIT__A	VIT__C	IODINE
0.36994437	0.68954247	0.65157947	0.63493009	0.37632323

The FACTOR Procedure
Rotation Method: Varimax

Orthogonal Transformation Matrix

	1	2	3
1	0.99086	0.11315	0.07339
2	-0.12708	0.96553	0.22716
3	0.04516	0.23441	-0.97109

Rotated Factor Pattern

		Factor1	Factor2	Factor3
ENERGY	ENERGY	6	87 *	-8
PROTEIN	PROTEIN	12	0	-44 *
FAT	FAT	-21	74 *	-10
THIAMINE	THIAMINE	76 *	-1	-16
RIBOFLVIN	RIBOFLVIN	79 *	3	1
NIACIN	NIACIN	43 *	-29	-31
IRON	IRON	83 *	1	1
VIT__A	VIT# A	28	59 *	47 *
VIT__C	VIT# C	48 *	12	63 *
IODINE	IODINE	-16	-28	52 *

Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3
2.4727556	1.8333856	1.2176093

Final Communality Estimates: Total = 5.523750

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.76750112	0.20765039	0.59873250	0.60494499	0.62260184

NIACIN	IRON	VIT__A	VIT__C	IODINE
0.36994437	0.68954247	0.65157947	0.63493009	0.37632323

Results for Principle components analysis setting eigenvalue at 1

The FACTOR Procedure

Means and Standard Deviations from 144 Observations

Variable	Mean	Std Dev
ENERGY	333.40278	157.68639
PROTEIN	22.18194	59.08000
FAT	11.93757	32.30616
THIAMINE	0.33119	0.32331
RIBOFLVIN	0.26647	0.40501
NIACIN	5.47614	4.72587
IRON	5.24590	5.77548
VIT__A	104.48849	237.51300
IODINE	29.00347	250.26052

The FACTOR Procedure
Initial Factor Method: Principal Components

Prior Communality Estimates: ONE

Eigenvalues of the Correlation Matrix: Total = 9 Average = 1

	Eigenvalue	Difference	Proportion	Cumulative
1	2.30761578	0.47342413	0.2564	0.2564
2	1.83419165	0.77108627	0.2038	0.4602
3	1.06310538	0.09375985	0.1181	0.5783
4	0.96934553	0.12497639	0.1077	0.6860
5	0.84436913	0.08462327	0.0938	0.7798
6	0.75974586	0.19925680	0.0844	0.8643
7	0.56048907	0.18524285	0.0623	0.9265
8	0.37524621	0.08935482	0.0417	0.9682
9	0.28589139		0.0318	1.0000

3 factors will be retained by the MINEIGEN criterion.

The FACTOR Procedure
Initial Factor Method: Principal Components

```
Scree Plot of Eigenvalues
      ,
      ,
      ,
      ;
  2.5 ˆ
      ,
      ,
      ,               1
      ,
      ,
      ;
  2.0 ˆ
      ,
      ,                        2
      ,
      ,
E     ,
i     ;
g 1.5 ˆ
e     ,
n     ,
v     ,
a     ,
l     ,
u     ,                                 3
e 1.0 ˆ                                          4
s     ,
      ,                                                   5
      ,                                                            6
      ,
      ,
      ;                                                                     7
  0.5 ˆ
      ,
      ,                                                                              8
      ,                                                                                       9
      ,
      ,
      ;
  0.0 ˆ
      ,
      ,
      ,
      ;
      Šƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒ
             0        1        2        3        4        5        6        7        8        9

                                                   Number
```

The FACTOR Procedure
Initial Factor Method: Principal Components

Factor Pattern

		Factor1	Factor2	Factor3
ENERGY	ENERGY	8	86 *	-15
PROTEIN	PROTEIN	13	-8	-58 *
FAT	FAT	-18	73 *	-4
THIAMINE	THIAMINE	80 *	-1	9
RIBOFLVIN	RIBOFLVIN	81 *	6	21
NIACIN	NIACIN	46 *	-33	-19
IRON	IRON	81 *	0	-1
VIT__A	VIT# A	24	65 *	26
IODINE	IODINE	-16	-18	74 *

Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3
2.3076158	1.8341916	1.0631054

Final Communality Estimates: Total = 5.204913

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.76358751	0.36479552	0.56309944	0.64897757	0.70898353

NIACIN	IRON	VIT__A	IODINE
0.35524456	0.65328109	0.54450053	0.60244306

The FACTOR Procedure
Rotation Method: Varimax

Orthogonal Transformation Matrix

	1	2	3
1	0.98849	0.01754	-0.15025
2	-0.02163	0.99944	-0.02561
3	0.14972	0.02857	0.98832

Rotated Factor Pattern

		Factor1	Factor2	Factor3
ENERGY	ENERGY	4	85 *	-19
PROTEIN	PROTEIN	4	-10	-59 *
FAT	FAT	-20	72 *	-3
THIAMINE	THIAMINE	80 *	1	-4
RIBOFLVIN	RIBOFLVIN	83 *	8	8
NIACIN	NIACIN	43 *	-33	-25
IRON	IRON	80 *	1	-13
VIT__A	VIT# A	26	66 *	20
IODINE	IODINE	-5	-16	76 *

Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3
2.2794978	1.8337081	1.0917068

Final Communality Estimates: Total = 5.204913

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.76358751	0.36479552	0.56309944	0.64897757	0.70898353

NIACIN	IRON	VIT__A	IODINE
0.35524456	0.65328109	0.54450053	0.60244306

The FACTOR Procedure

Means and Standard Deviations from 144 Observations

Variable	Mean	Std Dev
ENERGY	333.40278	157.68639
PROTEIN	22.18194	59.08000
FAT	11.93757	32.30616
THIAMINE	0.33119	0.32331
RIBOFLVIN	0.26647	0.40501
NIACIN	5.47614	4.72587
IRON	5.24590	5.77548
VIT__A	104.48849	237.51300
VIT__C	5.58153	12.00785
IODINE	29.00347	250.26052

The FACTOR Procedure
Initial Factor Method: Principal Components

Prior Communality Estimates: ONE

Eigenvalues of the Correlation Matrix: Total = 10 Average = 1

	Eigenvalue	Difference	Proportion	Cumulative
1	2.48547603	0.62224222	0.2485	0.2485
2	1.86323382	0.68819321	0.1863	0.4349
3	1.17504061	0.20439832	0.1175	0.5524
4	0.97064229	0.02991742	0.0971	0.6494
5	0.94072487	0.09638427	0.0941	0.7435
6	0.84434060	0.16519391	0.0844	0.8279
7	0.67914670	0.18421383	0.0679	0.8959
8	0.49493287	0.19959585	0.0495	0.9454
9	0.29533702	0.04421183	0.0295	0.9749
10	0.25112519		0.0251	1.0000

4 factors will be retained by the MINEIGEN criterion.

```
Results for principle components analysis excluding vitamin C and setting eigenvalue at 1 to includ 64
                                                                            12:15 Sunday, July 6, 2008

                                         The FACTOR Procedure
                             Initial Factor Method: Principal Components

Scree Plot of Eigenvalues
      ,
      ,
      ,
      ,
  2.5 ˆ               1
      ,
      ,
      ,
      ,
      ,
      ,
  2.0 ˆ
      ,
      ,                       2
      ,
      ,
E     ,
i     ,
g 1.5 ˆ
e     ,
n     ,
v     ,
a     ,
l     ,                               3
u     ,
e 1.0 ˆ                                       4
s     ,                                               5
      ,                                                       6
      ,
      ,                                                               7
      ,
      ,
  0.5 ˆ                                                                       8
      ,
      ,
      ,                                                                               9       0
      ,
      ,
      ,
  0.0 ˆ
      ,
      ,
      ,
      ,
      Šƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒ
              0       1       2       3       4       5       6       7       8       9      10

                                                   Number
```

The FACTOR Procedure
Initial Factor Method: Principal Components

Factor Pattern

		Factor1	Factor2	Factor3	Factor4
ENERGY	ENERGY	15	81 *	28	4
PROTEIN	PROTEIN	9	-12	43 *	85 *
FAT	FAT	-13	72 *	26	-8
THIAMINE	THIAMINE	74 *	-14	18	-1
RIBOFLVIN	RIBOFLVIN	79 *	-7	3	-5
NIACIN	NIACIN	37	-41 *	25	-29
IRON	IRON	82 *	-10	3	6
VIT__A	VIT# A	38	64 *	-31	5
VIT__C	VIT# C	53 *	20	-56 *	9
IODINE	IODINE	-15	-13	-58 *	37

Printed values are multiplied by 100 and rounded to the nearest integer.
Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3	Factor4
2.4854760	1.8632338	1.1750406	0.9706423

Final Communality Estimates: Total = 6.494393

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.76944979	0.93084026	0.60544737	0.60500521	0.62477471

NIACIN	IRON	VIT__A	VIT__C	IODINE
0.45621907	0.69260443	0.65444142	0.64343405	0.51217646

The FACTOR Procedure
Rotation Method: Varimax

Orthogonal Transformation Matrix

	1	2	3	4
1	0.96830	0.10390	0.22689	0.01066
2	-0.16407	0.94313	0.27280	-0.09574
3	0.16085	0.31350	-0.84856	0.39470
4	-0.09797	-0.03781	0.39248	0.91375

Rotated Factor Pattern

		Factor1	Factor2	Factor3	Factor4
ENERGY	ENERGY	5	87 *	3	8
PROTEIN	PROTEIN	9	0	-4	96 *
FAT	FAT	-19	75 *	-9	-4
THIAMINE	THIAMINE	77 *	0	-3	9
RIBOFLVIN	RIBOFLVIN	78 *	3	11	-2
NIACIN	NIACIN	50 *	-26	-36	-13
IRON	IRON	81 *	0	16	8
VIT__A	VIT# A	21	55 *	54 *	-13
VIT__C	VIT# C	39	7	68 *	-15
IODINE	IODINE	-25	-33	57 *	12

Printed values are multiplied by 100 and rounded to the nearest integer.
Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3	Factor4
2.4202844	1.8010388	1.2622305	1.0108390

Final Communality Estimates: Total = 6.494393

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.76944979	0.93084026	0.60544737	0.60500521	0.62477471

NIACIN	IRON	VIT__A	VIT__C	IODINE
0.45621907	0.69260443	0.65444142	0.64343405	0.51217646

The FACTOR Procedure

Means and Standard Deviations from 144 Observations

Variable	Mean	Std Dev
ENERGY	333.40278	157.68639
PROTEIN	22.18194	59.08000
FAT	11.93757	32.30616
THIAMINE	0.33119	0.32331
RIBOFLVIN	0.26647	0.40501
NIACIN	5.47614	4.72587
IRON	5.24590	5.77548
VIT__C	5.58153	12.00785
IODINE	29.00347	250.26052

The FACTOR Procedure
Initial Factor Method: Principal Components

Prior Communality Estimates: ONE

Eigenvalues of the Correlation Matrix: Total = 9 Average = 1

	Eigenvalue	Difference	Proportion	Cumulative
1	2.41458663	0.83541059	0.2683	0.2683
2	1.57917604	0.47737787	0.1755	0.4438
3	1.10179817	0.13259042	0.1224	0.5662
4	0.96920775	0.04297505	0.1077	0.6739
5	0.92623269	0.11391457	0.1029	0.7768
6	0.81231812	0.28720982	0.0903	0.8670
7	0.52510830	0.13983328	0.0583	0.9254
8	0.38527502	0.09897773	0.0428	0.9682
9	0.28629729		0.0318	1.0000

4 factors will be retained by the MINEIGEN criterion.

The FACTOR Procedure
Initial Factor Method: Principal Components

```
Scree Plot of Eigenvalues
      ,
      ,
      ,
      ,
  2.5 ˆ
      ,               1
      ,
      ,
      ,
      ,
      ,
  2.0 ˆ
      ,
      ,
      ,
      ,
E     ,
i     ,                        2
g 1.5 ˆ
e     ,
n     ,
v     ,
a     ,
l     ,
u     ,                                 3
e 1.0 ˆ                                          4
s     ,                                                   5
      ,
      ,                                                            6
      ,
      ,
      ,
  0.5 ˆ                                                                     7
      ,
      ,                                                                              8
      ,                                                                                       9
      ,
      ,
      ,
  0.0 ˆ
      ,
      ,
      ,
      ,
      Šƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒ
             0        1        2        3        4        5        6        7        8        9

                                                Number
```

The FACTOR Procedure
Initial Factor Method: Principal Components

Factor Pattern

		Factor1	Factor2	Factor3	Factor4
ENERGY	ENERGY	0	88 *	-5	6
PROTEIN	PROTEIN	12	-4	-56 *	78 *
FAT	FAT	-25	76 *	-3	-3
THIAMINE	THIAMINE	77 *	11	-3	5
RIBOFLVIN	RIBOFLVIN	78 *	6	0	-2
NIACIN	NIACIN	45 *	-31	-40	-35
IRON	IRON	84 *	13	9	8
VIT__C	VIT# C	46 *	13	55 *	7
IODINE	IODINE	-14	-28	56 *	46 *

Printed values are multiplied by 100 and rounded to the nearest integer.
Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3	Factor4
2.4145866	1.5791760	1.1017982	0.9692077

Final Communality Estimates: Total = 6.064769

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.78061855	0.94384251	0.64664858	0.61168074	0.60728136

NIACIN	IRON	VIT__C	IODINE
0.57381067	0.73740925	0.53883092	0.62464600

The FACTOR Procedure
Rotation Method: Varimax

Orthogonal Transformation Matrix

	1	2	3	4
1	0.96745	-0.16209	-0.18511	0.05916
2	0.15782	0.98530	-0.05107	-0.04098
3	0.18292	-0.01425	0.77529	-0.60437
4	0.07534	0.05212	0.60171	0.79345

Rotated Factor Pattern

		Factor1	Factor2	Factor3	Factor4
ENERGY	ENERGY	13	87 *	-5	5
PROTEIN	PROTEIN	6	-1	2	97 *
FAT	FAT	-13	79 *	-3	-6
THIAMINE	THIAMINE	76 *	-2	-14	10
RIBOFLVIN	RIBOFLVIN	76 *	-7	-16	3
NIACIN	NIACIN	28	-39	-59 *	0
IRON	IRON	86 *	-1	-5	5
VIT__C	VIT# C	57 *	5	38	-25
IODINE	IODINE	-4	-24	75 *	3

Printed values are multiplied by 100 and rounded to the nearest integer.
Values greater than 0.4 are flagged by an '*'.

Variance Explained by Each Factor

Factor1	Factor2	Factor3	Factor4
2.3416524	1.5993713	1.1000231	1.0237218

Final Communality Estimates: Total = 6.064769

ENERGY	PROTEIN	FAT	THIAMINE	RIBOFLVIN
0.78061855	0.94384251	0.64664858	0.61168074	0.60728136

NIACIN	IRON	VIT__C	IODINE
0.57381067	0.73740925	0.53883092	0.62464600