The nutritional value of *Moringa oleifera* Lam. leaves: what can we learn from figures?

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Introduction

There are quite a lot of data available in the literature, on the Internet and from other sources about the nutritional value of *Moringa oleifera* Lam. (M.o.) leaves. However, it can sometimes be quite hard to find one's way through, since there can be considerable variation amongst data.
In this context, we thought it might be useful for fieldworkers and for efficient communication about Moringa, to have reliable average figures on the nutritional value of M.o. leaves.
The objective of this work was to gather available information about M.o. leaves nutritional value, to identify potential sources of errors in data, to discard irrelevant data, and to find a consensus on average nutritional values.

Methodology

We did an exhaustive search for data on the nutritional value of M.o. leaves through literature databases, the Internet, and the Moringanews Network. All the data collected where compiled in a Microsoft Excel spreadsheet for further analyses. When there were several analyses in one reference, they were compiled in order to give the same weight to each reference. All the data collected, whether from fresh or dry leaves, were transformed to obtain a value for 100g of dry matter, using the water content given in the analysis if available, or using the average water content for fresh or dry leaves, accordingly, if not. Data for vitamin A were all converted to International Units (UI) using a conversion factor beta-carotene to retinol of 1/6 and 1UI=0.3µg retinol, except in Figure 3 where a conversion factor of 1/18 has been used to avoid overestimation. For vitamin C, only values for fresh leaves have been considered, since there is a loss a vitamin C when the leaves are dried, except in Figure 3 where we used the value for dry leaves, since this Figure is dealing with leaf powder.
We then calculated, for each nutrient, the mean, the standard deviation and the ratio of the maximal to the minimal value. In order to eliminate irrelevant values, we discarded outliers for each nutrient.
We then recalculated the mean and the standard deviation for the data kept. So obtained mean values were then compared to other foods and to the recommended dietary allowances.
We also compared the discarded data to the mean values to try to understand the potential causes of such high variations or errors.

Results

1. Source data

In total, we collected **23 references** dealing with M.o. nutritional values, 11 of them were from peer reviewed journals, 5 from books or reports, 5 from unpublished analyses, and 2 from an Internet source (FAO).

2. Variability of source data

The ratio of the maximal to the minimal value in initial data varied from 1.9 to 514 (**Table 1**), illustrating the very high variability of source data. Furthermore, the high variability of source data is illustrated by **Figure 1**, which shows the standard deviation for each nutrient.

3. Selection of relevant data

Table 1 shows the ratios of maximal to minimal values obtained after having discarded outliers (the number of figures kept is indicated in parentheses). **Figure 1** illustrates the remaining variability of selected data, by showing the standard deviation for each nutrient.

Nutrient	Ratio Maximum Value/Minimum Value	
	Source data	Selected data
Minerals	**1.9** (9)	**1.9** (9)
Manganese	**1.9** (7)	**1.9** (7)
Carbohydrates	**4** (8)	**1.6** (6)
Vitamin C*	**4** (8)	**0.8** (5)
Fibers	**6** (8)	**1.7** (4)
Vitamin E	**8** (3)	**N/A**
Calcium	**19** (16)	**1.7** (13)
Proteins	**24** (15)	**1.8** (11)
Fat	**25** (11)	**1.9** (5)
Copper	**29** (10)	**2.2** (8)
Iron	**30** (14)	**2.1** (10)
Vitamin A	**42** (10)	**2.9** (7)
Phosphorus	**64** (11)	**1.5** (5)
Magnesium	**76** (9)	**1.4** (6)
Vitamin B2	**111** (3)	**N/A**
Zinc	**121** (10)	**2.1** (7)
Vitamin B1	**340** (4)	**N/A**
Potassium	**514** (8)	**2.2** (6)

Table 1: Ratio of maximum to minimum value for the whole set of data (left column) and for the selected set of data (right column). The figures in parentheses indicate the number of data considered.
*Vitamin C: values for fresh leaves only.

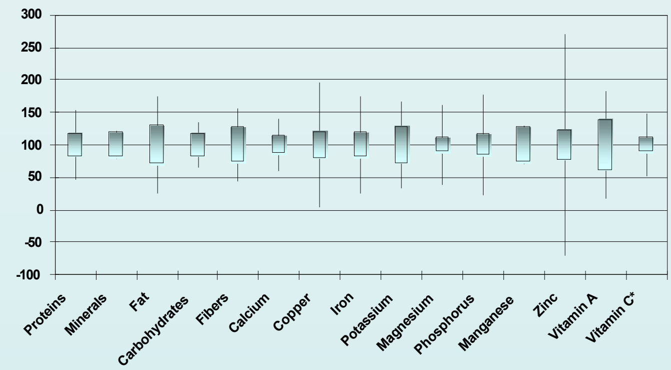

Figure 1: Representation of the variability of data. Means for all nutrients have been set to 100 arbitrary units. Thin lines represent the standard deviation for the whole set of data, while boxes represent the standard deviation for the set of selected data. *Vitamin C: values for fresh leaves only.

4. Possible sources of variation amongst data

Table 2 illustrates the possible sources of variation amongst data. While there is generally an acceptable range of variation due to differences in the genetic background, the environment, the cultivation methods and the sample analytical method, attention must be drawn on variations due to the methods of preparation and conservation of samples that can seriously affect the vitamin content. As far as errors of Human origin are concerned, they should be as far as possible identified and the values not taken into account.

Table 2: Possible sources of variations amongst data	
Natural variation amongst source samples	
Genetic background (ecotype, cultivar) Environment (soil, climate, pathogens) Cultivation methods (inputs, frequency of harvests)	Ex: calcium content varies from 1400 to 2300 mg/100g DM in the selected data
Variation due to sample preparation and analysis	
Time between collection and analysis Mode of conservation between collection and analysis (drying, refrigeration, freezing, etc.) Analytical method	Ex: vitamin C content is 40 times lower in dried leaves (around 20 mg/100g DM) compared to fresh leaves (around 800 mg/100g DM)
Errors of Human origin	
Error of manipulation during analysis Error in the calculation of results Error in the edition of results Error in the botanical identification of the sample	Ex: the values for zinc vary between 0.5 and 3.6 mg/100g DM, except for one value which is 26 mg/100g DM (ref.2), while the average value is 2.5mg/100g DM. Ex. in ref.21, data reported for 100 mg dried leaves are: proteins=72mg; calcium=690 mg; iron=3.5mg; potassium=3.8mg; zinc=0.2mg; copper=0.15mg, vitamin C=1.1mg. These values are completely inconsistent with average values.

5. Comparison of mean nutritional values with other foods and RDA

Table 3 shows, for each nutrient for which sufficient data were available, the mean values obtained and the standard deviation.

Nutrient	Mean value for 100g Dry Matter
Proteins (g)	**29** ± 6
Minerals (g)	**11** ± 2.2
Fat (g)	**8** ± 2.5
Carbohydrates (g)	**38** ± 7
Fibers (g)	**10** ± 3
Calcium (mg)	**1924** ± 288
Copper (mg)	**1.0** ± 0.2
Iron (mg)	**28** ± 6
Potassium (mg)	**1384** ± 420
Magnesium (mg)	**422** ± 52
Phosphorus (mg)	**267** ± 49
Manganese (mg)	**8.4** ± 2.4
Zinc (mg)	**2.5** ± 0.6
Vitamin A (IU)	**15620** ± 6475
Vitamin C* (mg)	**773** ± 91

Table 3: Mean nutritional values of *Moringa oleifera* leaves. Data are given for 100g dry matter. *Data originate from the analysis of both fresh and dry leaf samples, except for vitamin C for which only analyses of fresh samples have been taken into account, due to the loss of vitamin C during the drying process.

Figure 2 shows the nutritional interest of M.o. leaves in country where the diet is deficient in proteins, vitamins and minerals. Fresh M.o. leaves contain at least twice more proteins than milk, and half the proteins of eggs. They are richer in iron than lentils and beef meat, richer in calcium than milk, at least as rich as carrots in vitamin A, and richer in vitamin C than oranges.

But **Figure 2** also highlights that Moringa is not a «miracle food», as similar properties can be found in other leafy vegetables like cassava or amaranth leaves.

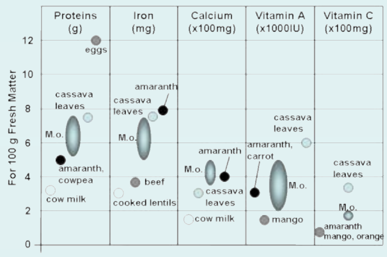

Figure 2: Comparison of the average nutritional values of *Moringa oleifera* fresh leaves with other foods. For M.o., the ellipsoid represents the range of acceptable values (mean +/- SD). For other foods, the circle indicates the mean value from *Food Composition Table for Use in Africa*, FAO, 1968.

Figure 3 highlights the interest of *Moringa oleifera* leaf powder to prevent malnutrition in developing countries, that mostly appear in children during the weaning period, between 1 and 3 years old. Indeed, for children under three, 30g of leaf powder can cover one third of the daily allowance for proteins, 75% of the calcium needs, more than half of the iron necessary, the totality of the recommended dietary allowance for vitamin A, and almost one third of the needs in vitamin C. The leaf powder is also an interesting dietary supplement for pregnant and lactating women.

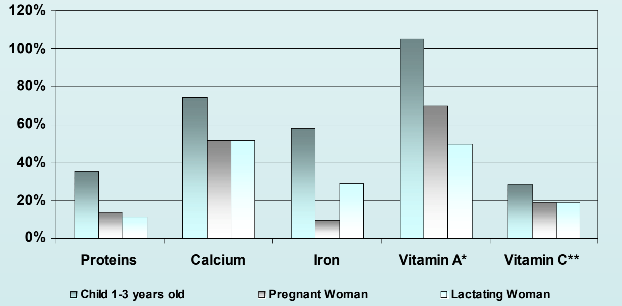

Figure 3: Percentage of coverage of recommended dietary allowance with 30g *Moringa oleifera* leaf powder, for children 1-3 years old, pregnant and lactating women. RDA are from *La nutrition dans les pays en développement,* Michael C. Latham, FAO, 2001, for a diet poor in proteins from animal sources and poor in vitamin C. *For vitamin A, to avoid overestimation, a conversion rate beta-carotene to retinol of 1/18 has been used instead of 1/6 generally used, since 1/18 is closer to the real conversion rate for leafy vegetables.
**Value for vitamin C originates from only two sources from the analysis of leaf powder (data from fresh leaves have not been taken into account since they would be overestimated for leaf powder).

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