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Valorization of Local Products to Fight Against Chronic Malnutrition in Malagasy Rural Households Using Food Supplements Bio-Fortified by The Leaves Powder of *Moringa oleifera Lam.*

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ABSTRACT:

In Madagascar, the national economy depends largely on the agriculture sector, dominated by smallholder farmers whose main primarily activities rely on subsistence. Decrease of per capita agricultural production has been observed. Over 70% of households live below the national poverty line (535.603 Ariary/year). Malagasy poverty has always been predominant in rural areas represented 86% of the poor live. The proportion of children between 6 - 23 months who received varied and nutritious diet is low (30.9% of children between 6-23 months received diverse complementary feeding), even in the richest households. In particular, vitamin A or iron-rich foods consumption for 6-23 months-aged children remains in low rates. The percentage of the population, exposed to food and nutritional insecurity, who consumed less than 2250 kcal per day and with 85% of calories coming from staple foods remained around 31~35%. Overall anaemia prevalence among children was 51.2% in 2013. Close to one third of female adolescents suffers from anaemia (35.3%) and underweight (27%), the latter showing the increasing trends for the period of 2004-2009. Feeding practices have been seriously inadequate with only 2.7% of children aged from 6 to 23 months received meals corresponding to the "minimum acceptable diet" standards in 2013. On the other hand, inadequate food practices are often the cause of malnutrition on nutritional improvement. To achieve the global nutrition targets, improving the status of major underlying drivers of nutrition has been recognized as an important dimension of Madagascar's nutrition programming. From this standpoint, food fortification by powder leaves of Moringa has the dual advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns.

Keyword: *Smallholder farmers, poverty, malnutrition, food fortification, Moringa oleifera.*

INTRODUCTION

Madagascar is one of the poorest countries in the World. The recurrent political crises have not led to major structural changes in the economy. Then, resulting in poor economic performance over the past 20 years, rampant poverty over the years ranges between 70 and 80% [1]. The country has regressed in its ranking from 135th in 2010 to 151st in 2012 according to the Report on Human Development. In Madagascar, people living under the national poverty line (535.603 Ariary/year) represent more than 70% [2]. The predominance of poverty is more observed in rural areas with 86% live poorly.

In 2012, about 31% of households were food insecure.

The "food insecurity" is defined as: the consumption is very low in quantity (less than 2250 kcal per day) and extremely poor quality (over 85% of the calories come from staple foods) [3]. The percentage of the food insecure population remained around 31~35% between 2005 and 2014. This indicates that around a third of the population has been food insecure in the past 10 years [4][5]

The quantitative and qualitative deficiencies affect a very large part of the Malagasy population. As shown in figure 1, the household food insecurity is linked to poverty, which affects the entire population in the country. The number of calories consumed is directly related to the household poverty level. Households in the poorest wealth quintiles were more likely to be food insecure. Among the poorest wealth quintile, 64% of households are food insecure. Between 2010 and 2013, the proportion of food insecure people fell among the richest households but remained relatively stable in the poorest households.

Furthermore, the diversity diet of households does not seem to depend on the household poverty level. The share representing the basic food in the diet of households is very high regardless of the wealth quintile (86% for the poorest quintile and 77% for quintile of the richest households).

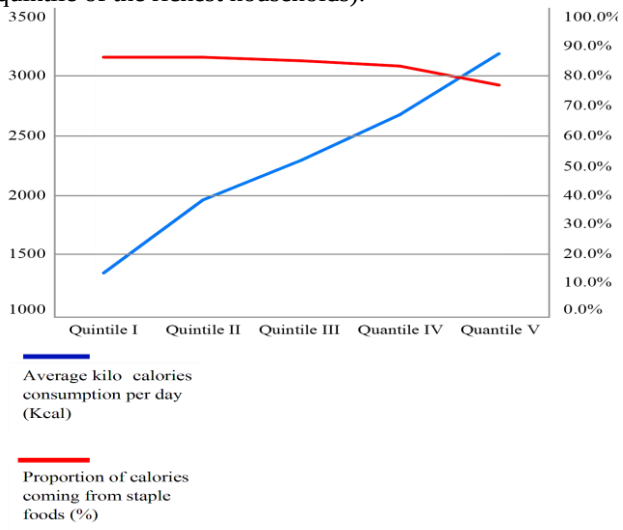

Figure 1: Food Consumption in Quality and Quantity According to Wealth Quintiles [5]

Table 1 shows the food insecurity situation, underweight among children under-5 (CU5), stunting CU5 in the five poorest regions in Madagascar. From this table, it is obvious that food insecurity does not necessarily coincide with underweight or stunting. The highest food insecurity is found in the south-central coast, whereas the highest prevalence of underweight and stunting are found in the central highlands where the food insecurity scores are lower than the national average.

Table 1: Food Insecurity, Underweight and Stunting in Children under Five in the Poorest 5 Regions [1][6]

Regions with Poverty Rates above 85%	Highest Food Insecurity Rates	Underweight Rate of Children Under 5	Stunting Rate of Children Under 5
Androy (South)	31.9%	26.9%	46.7%
Atsimo Atsinanana (South-central Coast)	64.1% (Highest in Madagascar)	26.7%	49.9%
Vakinankaratra (Central Highlands)	23.7%	41.6% (Highest in Madagascar)	71.1% (Highest in Madagascar)
Amoron'i Mania (Central Highlands)	30.5%	35.9% (Third Highest in Madagascar)	61.3% (Second Highest in Madagascar)
Anosy (South)	33.8%	24.5%	47.4%
Average	31% (National)	27.9% (Rural)	48.7% (Rural)

MATERIALS AND METHODS

To improve the nutritional status of children under five years and pregnant women, the fortification of local products in the form of fortified flours is necessary. In this case, all the nutrients necessary for nutritional needs are in quality and quantity equal. The raw material very useful for the fortification products is the Moringa Oleifera (MO) leaves.

In this case, fresh MO leaves were collected from five distant towns of Madagascar: Antananarivo (center), Antsiranana (northern coast), Toamasina (eastern coast), Mahajanga (western coast) and Toliara (southern coast).

Two series of harvests were performed. The first batches of fresh leaves, for the analysis of dry matter, ash content, minerals, crude proteins, and crude fat, were harvested in April 2012 in the five locations. The second batches, for the analysis of fatty acids and amino acids, were collected only in Antananarivo and Antsiranana. The green leaves were first separately cleaned, then sun-dried and finally milled into powder using mixer used traditionally in family kitchen. Manipulations of leaves when drying and grinding were similar to avoid variation due to sample preparation. The powders were then stored in well-dried plastic container and protected from light at about 6°C [6]

Moisture content was determined by drying of leaf powders in oven at 45°C for 24h and ash content was obtained after incineration at 600°C for 3 hrs [7].

Minerals quantification

500 mg of leaf powders were incinerated at 600°C, weighed and desilicated with 1 mL of 37% chlorhydric acid (Panreac Quimica, Castellar del Vallès, Spain) and 1 ml of 1 mol.L-1 of HCl (Panreac Quimica, Castellar del Vallès, Spain)[8]. The obtained solution was then evaporated at high temperature. The residue was mixed with distilled water and filtered.

Detection of calcium (Ca), magnesium (Mg) and iron (Fe) were performed using flame atomic absorption spectrophotometry. Element concentrations were determined to use specific calibration of six points for Ca and Mg and 7 points for Fe, in the range 0 to 5 mg/L for Ca, 0 to 2.5 mg/L for Mg and 0 to 30 mg/L for Fe.

Data analysis

Each analysis was performed in triplicate and all the results are reported as mean, except for the analysis concerning amino acids which was not repeated. Data were analyzed using one-way ANOVAs or Student t-tests. Newman Keuls test (SNK) was used to identify significant differences among treatment means. The software XLSTAT 2013 (Addinsoft France) was used for statistical analysis. Data was considered significant at $p < 0.05$ [9].

RESULTS AND DISCUSSION

Protein content in MO leaves from the five locations was from 23.5 to 29.7%. CF varied from
5.2 to 7.5%, Ca from 974 to 2714 mg/100g, Mg from 271 to 460 mg/100g and Fe from 3.8 to
8.3 mg/100g. The ash contents were from 9.71 to 11.48% and the moisture content from 6.34 to 8.46%.

Total carbohydrates proportion was estimated by deduction to be from 44.7 to 54.8%. All the values are expressed on dry matter (DM).

The sample from Antsiranana had the highest quantity of crude protein (29.7%) and the leaf powder from Mahajanga the lowest (23.5%). The sample from Toliara had the highest quantity of crude fat (7.5%) compared to the dried leaves from the other locations whose fat content was similar.

The dried leaves from Antananarivo had the highest quantity of calcium (2714.3mg/100g) and there was no significant difference of quantity of Ca between the four other samples. The highest quantity of magnesium was observed in the sample from Mahajanga (460.7 mg/100g), and the lowest quantity of Mg was observed in the samples from Antsiranana, Toamasina and Antananarivo. The highest quantity of iron was observed in the sample from Antsiranana (8.3 mg/100g) and the dried leaves from Toliara had the lowest quantity of Fe (3.8 mg/100g).

Table 2. Macronutrients and minerals composition of Malagasy Moringa oleifera leaf powders from different locations

Table 2. Macronutrients and minerals	Antananarivo	Toliara	Mahajanga	Toamasina	Antsiranana
Ash (g/100g DM)	10.9 b	10.5 c	9.7 d	10.6 c	11.5 a
CP (g/100g DM)	28.4 b	26.6 c	23.5 d	27.0 c	29.7 a

CF (g/100g DM)	5.5 b	7.5 a	5.3 b	5.2 b	5.7 b
Ca (mg/100g DM)	2714.3 a	974.5 b	1327.7 b	1387.7 b	1156.7 b
Mg (mg/100g DM)	289.9 c	360.8 b	460.7 a	280.0 c	271.5 c
Fe (mg/100g DM)	6.2 b	3.8 c	6.2 b	5.4 b	8.3 a

[The highest values for each nutrient are in bold. Means bringing the same letter were not significantly different from Neuman Keuls test at α = 0.05. DM: Dry Matter, CP: Crude Protein, CF: Crude Fat [9].

Physico-chemical analysis results of Moringa leaves made within the Center National Environmental Research demonstrate the presence of fairly high levels of calcium 1.58g/100g compared to research of Delveau & Boiteau (1980) with a calcium level in 100g of dry matter equivalent to 440 mg. It is the same for the lipid content (5,10g / 100g of dry matter much higher than that given by the reference) On the other hand the rate of proteins obtained (15.6g/100g of material) is very low compared to the value given by the reference (67g/100g of dry matter) [9][10]. In fact, the determination of other minerals and vitamins is limited by the high cost of testing.

The variation of the results can be explained by (1) The ecological change of the Moringa culture conditions like the mineralogical composition of the plantation soil, this has a direct influence on the physicochemical composition of the plant, (2) The period of collection of analytical samples; during the rainy period the soil constituents are almost eliminated by the abundance of rain or the plant absorbs a lot of water instead of nutrients, hence the lack of these elements and (3) The storage time of the samples before the analysis, among others, vitamin C is very labile and can disappear quickly during the conservation in the fresh state.

To achieve the global nutrition targets, improving the status of major underlying drivers of nutrition has been recognized as an important dimension of Madagascar's nutrition programming. The Global Nutrition Report 2016 assessed the country situations based on a set of indicators reflecting major underlying drivers associated with stunting outcomes, such as total calories in food supply (quantity of diet), percent of calories from non-staples (quality of diet), access to WASH, female secondary school enrollment ratio (maternal education), and female to male ratio in life expectancy (women's empowerment). The report presents a simulation of the estimated threshold values for each of these underlying drivers, above which a country would have a stunting rate of 15 % or below (15 % is selected as the cut-off as it is approximately what the WHA target would have been for 2025; see the Global Nutrition Report 2016 for the detailed estimation method). As shown in table 1, all the indicators remain below the threshold, underscoring the need to address the basic development issues that affect the nutrition status of Malagasy people [4][5].

Being a food-based approach, food fortification offers a number of advantages. These include:

If consumed on a regular and frequent basis, fortified foods will maintain body stores of nutrients more efficiently and more effectively than will intermittent supplements. Fortified foods are also better at lowering the risk of the multiple deficiencies that can result from seasonal deficits in the food supply or a poor quality diet. This is an important advantage to growing children who need a sustained supply of micronutrients for growth and development, and to women of fertile age who need to enter periods of pregnancy and lactation with adequate nutrient stores.

Fortification generally aims to supply micronutrients in amounts that approximate to those provided by a good, well-balanced diet. Consequently, fortified staple foods will contain "natural" or near natural levels of micronutrients, which may not necessarily be the case with supplements.

Fortification of widely distributed and widely consumed foods has the potential to improve the nutritional status of a large proportion of the population, both poor and wealthy.

Fortification requires neither change in existing food patterns which are notoriously difficult to achieve, especially in the short-term nor individual compliance [11].

CONCLUSION

This study showed that current food practices in Madagascar are underlined by an interaction between food availability and accessibility due to the low income of the householder. To decrease children under-nutrition, Food Fortification is largely important and socially acceptable. Food Fortification does not require active consumer participation or changes in cooking or eating habits if organoleptic properties are maintained. When the different sectors of society participate actively as partners, successful programs are more likely to result. These should include relevant government institutions, the food industry, trade organizations, consumer organizations, academic and research facilities, marketing specialists, and interested international organizations and agencies. For example, the overall responsibility for quality control inside the country often rests with the Public Health Department, but consumer organizations can and should be involved.

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