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EVALUATION OF VITAMIN A DEFICIENCY RISKS AMONG LACTATING MOTHERS IN NGAOUNDERE, ADAMAWA REGION OF CAMEROON

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The aim of this study was to examine the risks and possible causes of Vitamin A deficiency among selected lactating mothers in Ngaoundere, Adamawa Region, Cameroon. A total of one hundred lactating mothers with children between 0 and 4 months attending pediatric visits at four health structures in Ngaoundere were involved in a 2013 survey using a 24-hour dietary recall to assess their dietary intake. Carotenoids were quantified in the meals commonly consumed and potentially rich in vitamin A, as well as proteins, sugar, fibers and oil. The results indicated that the dietary intake of Vitamin A was inadequate with 34% of the selected lactating mothers exposed to acute Vitamin A deficiency. The daily consumption of Vitamin A was 641.16 ± 88.99 μg, corresponding to a contribution of 80.14% to their requirement. The dietary intake of macronutrients was adequate with a daily consumption of 107.31 ± 8.73 g for oil, 280.79 ± 13.64 g for sugars, 59.67 ± 7.98 g for proteins and 21.72 ± 2.06 g for fibers corresponding respectively to a contribution of 119.2%, 112.3%, 99.5% and 86.9%% of their requirement. There is a need for urgent intervention programs in the area to alleviate this deficits.

Keywords: Lactating mothers, Vitamin A intake, Dietary intake, Vitamin A deficiency, Ngaoundere

INTRODUCTION

Vitamin A Deficiency (VAD) is a major public health problem in many developing countries, with children less than five years, individuals suffering from infectious diseases, pregnant and lactating women being the most at risk groups (Tchum *et al.*, 2009). VAD has primary and secondary causes. The primary causes of VAD are insufficient vitamin A intake due to unavailability or inaccessibility of vitamin A rich foods in the region (Ngaha *et al.*, 2014), food treatment (Djuikwo *et al.*, 2011) and socio-demographic, cultural and economic factors (Fombang *et al.*, 2016). Secondary causes are linked to absorption and metabolism of vitamin A (Thurnam *et al.*, 2000). Poor absorption and transport of provitamin and vitamin A are affected negatively by the lack in their diet of energy, fats (Prince and Frisoli, 1993), proteins and zinc (Dijkhuizen *et al.*, 2004), excess of fibers (Rock and Swendseid, 1992) or parasitic infections (IVACG, 2003). VAD can lead to night blindness, growth impairment, anemia, weakness of immune system and increased maternal and infant mortality (Tchum *et al.*, 2009).

Lactating women from developing countries are considered as a nutritionally vulnerable group because of the high nutritional demand for their babies (Ukegbu, 2014). Inadequate maternal diet during this period will lead to poor secretion of nutrients in breast milk and this can have long term impact on the child's health (Picciano, 2001; and Jones *et al.*, 2010). Under nutrition in general and VAD in particular in children usually follows from a deficiency in the mother. In Nigeria, a nationwide food consumption and nutrition survey carried out showed that 13% of mothers suffered

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from VAD (Tyndall *et al.,* 2012). In Cameroon, studies on VAD were focused mostly on children less than 5 years old and pregnant women, with limited information on lactating women. Existing data shows that Cameroon has a prevalence rate of 40 % for VAD. The Northern Regions (Adamawa, North and Far-North) are mostly affected with 62,5% of children less than 5 years old being affected by the deficiency, compared to the prevalence rate of 17.5% in the Southern Regions (HKI, 2015). For pregnant women in the town of Ngaoundere (Adamawa Region), 30% are exposed to slight VAD, 35% are at risk of acute VAD while 20% are at risk of severe VAD (Ngaha *et al.,* 2014).

Addressing the problem of VAD in post-partum women will certainly go a long way towards reducing the prevalence of VAD, not only in lactating mothers but also in their children. This therefore calls for the need to evaluate the risk of VAD and possible causes among lactating mothers in the town of Ngaoundere. This study will be useful for decision makers and stakeholders to design appropriate and targeted nutrition intervention programs to alleviate VAD in this region.

MATERIAL AND METHODS

Site of the Study

The study was conducted in the town of Ngaoundere, in the Adamawa Region of Cameroon, whose characteristics have previously been described by Ngaha *et al.* (2014).

Sampling of Subjects

The studied group was mainly made of lactating women carrying out vaccination and pediatric consultations of their babies in four health structures in the town of Ngaoundere; the Regional Hospital, the Protestant Hospital, the health district of Boumdjéré and the integrated health center of Sabongari, representing the various districts of the town of Ngaoundere.The sampled population therefore came from different backgrounds; urban, semi-urban and rural areas, that is from Ngaoundéré and some surrounding villages, from varied socio-economic, cultural and demographic groups, forming a mixed social background.

Any lactating woman aged from 15 to 40 years old, practicing exclusive breast-feeding, having a baby of less than 4 months, being under no medication nor particular diet, and having given her consent was recruited. All those who did not meet these criteria were excluded from the study.The stage of recruitment lasted two weeks, from 22nd April to10th May 2013, period during which socio-demographic information was collected and anthropometric data measured. These included age, weight, height, level of education, professional status, marital status, religion, number of children and age of baby. Informed consent was obtained from the women and the study period on the field lasted for two months. Ethical approval for this study was obtained from the ethical committee of the Regional Hospital in Ngaoundere.Of the 115 subjects interviewed who had initially given their consent to participate in the study, only 100 effectively took part.

Food Follow-Up of Participants and Collection of Meal Samples

Subjects were interviewed at home and nutrition information was obtained using the 24 hour dietary recall method for sixty days, from 4th June to 2nd August 2013. Information on type, place, quantity and frequency of meals consumed was collected. A survey was also made of the culinary practices and samples of meals potentially rich in vitamin A and commonly consumed by the post-partum women were retained for carotenoid analysis and quantification of macronutrients.

Meal samples were collected in clean, tightly closed glass containers, labeled and transported in dark containers to the Food Biophysics and Nutritional Biochemistry Laboratory of the National School of Agro IndustrialSciences of the University of Ngaoundere. They were then dried at 45 °C ± 2 °C for 48 hours and frozen at – 20 °C for subsequent analyses. Nineteen samples were collected representing the dishes potentially rich in vitamin A and most consumed by lactating women in Ngaoundere town.

Quantification of Carotenoids and Estimation of Vitamin A

To 1 g of dried sample, 30 ml of hexane-acetone mixture 30/70 (v/v) was added, and the mixture heated under reflux for one hour, cooled and filtered (AOAC, 1975). The filtrate was washed with distilled water in a separating funnel, the lipid phase was then decanted into a 25 ml graduated flask and the volume adjusted to the mark with hexane. The solution obtained was diluted (1/10) with hexane and the optical density read using a spectrophotometer Rayleigh (VIS-723N) between 430 and 450 nm in order to determine the maximum optical density. Carotenoids were then quantified using the relationship:

$C = \frac{(DOmax \times f)}{(196 \times m)}$. Where, DO_{max} is optical density where max absorption was obtained; *f*, dilution factor; and *m*, mass of the sample.

The Vitamin A content of the meals consumed was computed using the values of carotenoids determined earlier and based on the assumption that 12 μg of dietary carotenoid yields 1 μg of Vitamin A (WHO, 1982). Vitamin A from animal products were obtained from Food Composition Tables (West*et al.*, 1987; and FAO, 2012).

Quantification of Macronutrients

In order to determine the cause of VAD in the studied population,dry matter (AFNOR, 1982), oil (Bourely, 1982), total proteins (AFNOR, 1984; and Devani *et al.*, 1989), total sugars (Dubois *et al.*, 1956) and crude fibers (Wolff, 1968) contents of meals weredetermined to establish their effect on Vitamin A absorption and metabolism.

Calculation of Dietary Intakes

Vitamin A, protein, fats, fibers and sugar intake were obtained by summing intakes coming from vegetable and animal fractions from various dishes consumed during the study period. This was obtained from the laboratory analyses of the meal samples and from food composition tables. Thus, the daily Vitamin A and nutrient intake was the mean consumption per woman, per day during the period of study, and the general intake for all the studied population was the mean consumption for all the women.

Statistical Analysis

The data obtained in this study was subjected to analysis of variance (ANOVA) and means separated using the least significant difference test with the statistical software Statgraphics centurion at the 5% level of significance. Microsoft Excel 2013 was used to generate the graphs. Where appropriate, percentages (%) were calculated. Results are presented as means and standard deviation of three determinations.

RESULTS

Characteristics of the Studied Population

Table 1 shows the distribution of the studied population with respect to measured socio-demographic and anthropometric parameters. About 21% of the women had never gone to school, and only 26% had reached primary school. A small proportion (8%) had university education.A total of 77% of these women were married with only 23% being single. Most of them however, were housewives (59%) while 27% practiced some income generating activity (employed, petit traders, farmers). A proportion of 41% were Muslims, 59% being Christians. A total of 75% of women had two or more children including the child/children being

Table 1: Socio-Demographic and Anthropometric Parameters of the Studied Population

Parameters	Range	Percentage of Women
Level of education	None	21
	Primary education	26
	Secondary education	45
	University education	8
Marital status	Married	77
	Single	23
Religion	Muslim	41
	Christian	59
Number of children	0	25
	1	26
	2	17
	?3	32
Age of the mother (years)	[15-20[	16
	[20-30[	56
	[30-40]	28
Age of the baby (months)	< 1	11
	[1-2[	35
	[2-3[	35
	[3-4]	19
Socio-professional status	Housewife	59
	Worker	27
	Schoolgirl	12
	Student	2
BMI (kg/m²)	[18.9 – 24.9]	51
	[25 – 29.9]	40
	[30 – 34.9]	9

breast-fed, compared to only 25% who were at their first childbirth.In addition to their illiteracy and their multiple deliveries, 72% of the women were under 30 years of age. Of these 16% were between the ages of 14 and 20 years, whereas 56% were between 21 and 30 years. Concerning the age of the baby, 11% of the studied population had a baby of less than one month while 89% of the babies had more than one month. About half of the women (51%) had normal Body Mass Index (BMI) between18.5 and 24.9 kg/m². Forty percent (40%) of the women were overweight with a BMI between 25 and 29.9 kg/m², and 9% had primary obesity with BMI between 30 and 34.9 kg/m².

Food Follow-Up Results

From the 24 hours dietary recall method,the dishes potentially rich in vitamin A and most consumed by the studied population were indicated. Ten of these dishes were made using different leafy vegetables; Bokko (Baobab leaves) (*Adansonia digitata*), Eru (*Gnetum africanum*), Folere (*Hibiscus sabdarifa*), Folong (*Amaranthus acanthochiton*), Hako Mbaï (Cassava leaves) (*Manihot esculenta*), Giligandja (*Moringa oleifera*), Lalo (*Corchorus olitorius*), Ndole (*Vernonia colorata*), Tasba (*Cassia will tora Linnaeus*) and Zom (*Solanun nigrum*) and one made usinga leguminous plant, koki (*Vigna unguiculata*). Two methods of preparation each were identified for zom, folong and ndole, one with fresh groundnuts, called soup, and the other without but contained tomatoes and carrots, called fried. Eru and koki were cooked with red palm oil. The others dishes (hako mbaï, bokko, lalo) were cooked with local ingredients. The cereals and tubers commonly used to accompany these dishesthat were also collected were corn fufu (*Zea mays*) (white and yellow varieties) cassavafufu (*Manihot utilissima*), rice fufu (*Oryza sativa*), and boiled sweet potato (*Ipomea batatas*).The animal products consumed by these women were smoked and fresh fish, beef, chicken,pork, goat meat, lamb mutton and chicken eggs.

Nutritional Composition of the Dishes

Table 2 presents the nutritional compositions of the nineteen dishes and the staple foods (cereals and tubers) that accompany these dishescommonly consumed by thelactating women in Ngaoundere. The vegetables dishes on dry weight bases had high carotenoid contents varying from 27.56 ± 2.13 mg in Hako Mbaï to 81.59 ± 3.07 mg/100 g DW in Eru. Addition of tomatoes and carrots to the vegetables improved carotenoid content of the dishes, while additionof groundnuts improved protein content. Dishes in which palm oil was incorporated had high carotenoid contentas was the case with Eru and koki.Oil content in dishes varied from 19.55 ± 3.42 g in Giligandja to 48.31 ± 2.24 g /100 g dry weight (DW) in Eru, proteins from 28.79 ± 1.71 g in Eru to 49.97 ± 2.53 g/100 g DW in Giligandja and

Table 2a: Nutritional Composition of Dishes Commonly Consumed by Lactating Mothers

Dishes	Water (%)	Oil (g/100 g DW)	Proteins (g/100 g DW)	Sugar (g/100 g DW)	Fibers (g/100 g DW)	Carotenoids (mg/100 g DW)	Vitamin A (mg/100 g DW
Koki	64.28 ± 3.67[a]	31.69 ± 2.34[cd]	48.89 ± 3.05[h]	13.05 ± 1.49[d]	4.17 ± 0.77[a]	35.94 ± 1.47[c]	3
Bokko	87.15 ± 3.22[g]	29.72 ± 1.04[bc]	32.21 ± 1.84[abc]	17.35 ± 1.25[e]	15.41 ± 2.29[c]	37.59 ± 1.25[c]	3.13
Eru	75.12 ± 1.53[b]	48.31 ± 2.24[f]	28.79 ± 1.71[a]	6.51 ± 0.63[a]	12.13 ± 0.79[b]	81.59 ± 3.07[h]	6.8
Hako Mbaï	82.71 ± 2.56[defg]	25.89 ± 1.67[b]	40.51 ± 2.78g	17.44 ± 1.62[e]	15.41 ± 0.83[c]	27.56 ± 2.13[a]	2.3
Sauce Zom	81.72 ± 2.05[def]	35.82 ± 2.76[e]	35.70 ± 1.34[cde]	9.74 ± 0.43[c]	16.14 ± 0.81[cde]	40.98 ± 2.09[d]	3.42
Sauce Ndole	79.35 ± 1.79[bcde]	35.98 ± 3.17[e]	40.33 ± 2.98[fg]	7.45 ± 0.87[ab]	12.45 ± 2.58[b]	34.94 ± 3.14[c]	2.91
Sauce Folong	81.53 ± 3.16[def]	34.02 ± 2.39[de]	36.12 ± 1.75[de]	8.93 ± 0.74[bc]	15.76 ± 1.32[cd]	33.19 ± 3.93[bc]	2.77
Fried zom	78.72 ± 2.44[bcd]	29.96 ± 3.01[bcd]	31.19 ± 1.69[ab]	16.40 ± 0.83[e]	18.07 ± 2.37[cde]	63.30 ± 1.04[g]	5.28
Fried Ndole	76.34 ± 2.31[bc]	28.38 ± 2.46[bc]	36.81 ± 1.71[ef]	12.63 ± 0.91[d]	18.73 ± 2.69[e]	57.95 ± 2.88[ef]	4.83
Fried Folong	78.56 ± 3.09[bcd]	29.76 ± 2.39[bc]	32.98 ± 1.45[bcd]	13.99 ± 1.24[d]	18.69 ± 1.99[de]	55.39 ± 1.51[e]	4.62
Folere	83.95 ± 2.48[efg]	27.97 ± 2.08[bc]	32.72 ± 2.49[bcd]	16.55 ± 0.64[e]	18.44 ± 1.71[de]	31.08 ± 1.77[ab]	2.59
Lalo	84.04 ± 2.41[fg]	28.49 ± 1.68[bc]	31.74 ± 2.06[ab]	19.27 ± 1.33[f]	17.89 ± 1.28[cde]	29.76 ± 1.62[ab]	2.48
Tasba	81.43 ± 3.95[def]	26.39 ± 2.64[b]	34.59 ± 2.17[bcde]	17.26 ± 1.48[e]	17.93 ± 1.69[cde]	30.36 ± 1.58[ab]	2.53
Giligandja	80.17 ± 3.09[cdef]	19.55 ± 3.42[a]	49.97 ± 2.53[h]	17.50 ± 1.31[ef]	11.07 ± 1.66[b]	60.12 ± 2.43[fg]	5.01

Table 2b: Nutritional Composition of the Accompaniments of Dishes

Food	Water (%)	Oil (g/100 g DW)	Proteins (g/100 g DW)	Sugar (g/100 g DW)	Fibers (g/100 g DW)	Carotenoids (mg/100 g DW)	Vitamin A (mg/ 100 g DW)
Boiled sweet potato	60.38 ± 0.83[a]	2.72 ± 0.14[b]	5.01 ± 0.38[bc]	81.31 ± 2.45[a]	8.23 ± 1.04[ab]	0.64 ± 0.17[b]	0,05
Cassava fufu	63.61 ± 1.96[b]	2.00 ± 0.11[a]	4.15 ± 0.55[ab]	82.78 ± 2.84[a]	8.64 ± 1.37[ab]	0.12 ± 0.09[a]	0,01
White corn fufu	67.15 ± 1.14[c]	3.46 ± 0.33[c]	5.56 ± 0.74[c]	81.52 ± 3.11[a]	6.88 ± 1.01[a]	0.30 ± 0.12[a]	0,03
Rice fufu	65.29 ± 1.37[bc]	1.79 ± 0.17[a]	3.84 ± 0.39[a]	81.68 ± 3.04[a]	9.69 ± 0.85[b]	0.14 ± 0.05[a]	0,01
Yellow corn fufu	66.84 ± 2.01[c]	3.51 ± 0.72[c]	5.32 ± 0.41[c]	82.04 ± 1.09[a]	6.85 ± 0.90[a]	1.95 ± 0.11[c]	0,16

Note: Tables 2a and 2b: Figures in the same column followed by the same letter are not significantly different at ($p > 0.05$).

fibersfrom 4.17 ± 0.77 g in koki to 18.73 ± 0.61 g/100 g DW in fried Ndole. Cereals and tubers are good sources of energy with sugar content varying from 81.31 ± 2.45 g/100 g DWin boiled sweet potato to 82.78 ± 2.84 g/100 g DW in cassava fufu, but had low carotenoid contents, with cassava fufubeing the lowest (0.12 ± 0.09 mg/100 g DW).

The type and quantity of animal products consumed, their Vitamin A and protein contents were also presented in Table 3. Lactating women consumed on average 1332.8 g of animal proteins during the period of study (two months), hence a daily consumption of 22.21 g. From these foods, they obtained an estimated 4430 µg of VA during the same period, giving a daily consumption of 73.83 µg Vitamin A per lactating woman from animal sources.

Nutrientsintake of the Studied Population

Table 4 shows the average daily macronutrient, Vitamin A and fiber intake of lactating women in Ngaoundere. The intake of vitamin A and proteins were obtained by adding the contributions from the vegetable fraction of the dishes and those from the animal fraction and the average daily consumption of 641.16 ± 88.99 µg for vitamin A and 59.67 ± 7.98 g of proteins corresponding respectively to 75.4 and 99.5% of their daily requirements. Apart from fibers whose daily requirements are met at only 87%, the requirements for the other nutrients are met at over 100%, with 112% for sugars and 119% for oil.

Table 3: Types and Average Intake of Animal Foods by Each Lactating Woman per Day

Foods	Average Consumption (g)	Proteins (g)	Vitamin A (µg)
Chicken eggs	17.8	4	35.6
Smoked fish	13.9	2.4	0
Beef	13.3	2.4	3.3
Chicken	11.1	2.2	9.4
Lamb mutton	8.9	1.5	0.9
Fresh fish	6.9	1.4	0
Goat meat	3.3	0.6	0
Pork	2.3	0.3	-

Table 4: Average Daily Intakes of Nutrients per Lactating Woman

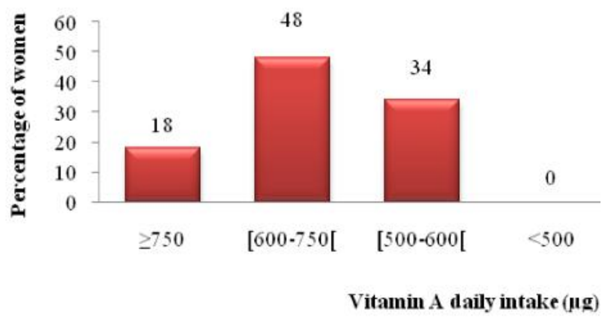
Nutrients	Intake/Day	RDA*	%age Coverage
Sugars (g)	280.79 ± 13.64	250 - 300	112.30%
Oil (g)	107.31 ± 8.73	90 - 105	119.20%
Proteins (g)	59.67 ± 7.98	60 - 70	99.50%
Fibers (g)	21.72 ± 2.06	25 - 30	86.90%
Vitamin A (µg)	641.16 ± 88.99	850 - 1200	75.40%

Note: * Recommended Daily Allowance (Food and Nutrition Board, Institute of Medicine, 2001; and Chen *et al.*, 2012).

Estimation of Vitamin A Deficiency Risk

Figure 1 shows the distribution of Vitamin A intake among the studied population and hence the percentage of pregnant women at risk for VAD. A total of 18% barely covered daily requirements in Vitamin A (>750 µg), 48% were exposed to slight VAD (650-749 µg), and 34% to an acute VAD (500-649 µg). There was no lactating woman at risk of severe VAD.

Figure 1: Classification of Lactating Mothers According to the Level of VAD Risk



DISCUSSION

With 21% of lactating women never been to school as against only 8% having reached the university level, the results in Table 1 showsthe extent of illiteracy of lactating women in the town of Ngaoundéré.A previous study on pregnant women in the same town revealed a 37% illiteracy rate (Ngaha *et al.,* 2014). This problem was also shown in a broader study carried out on the population of women in general in the Adamawa Region with an illiteracy rate of 39.5% (Kamgho *et al.,* 2012) (Ngaoundere is the capital of Adamawa region). Low literacy rate of the target populations constitutes a barrier to different nutritional intervention programs that could be implemented in the region like nutritional education through the media and clinical campaigns.The cultural practices in this part of the country can be the cause of this low literacy rate. With 72% of lactating women less than 30 years, and 16% of them of teenage age, it therefore becomes obvious that the young girls in Ngaoundéré get married and start child bearing very early in life thus preventing them from going to school. Ngaha *et al.* (2014) found 41% illiteracy rate for pregnant women between 14 and 20 years. This therefore confirms thatin this region, the average age of marriage is 16.3 years with 18.5 years beingthe average age of first childbirth (Fomo and Evina, 2012). The early marriage among these women is closely related to the number of children as approximately 50% of the studied population had at least three or more children (Table 1), consequently many mouths to feed with barely minimal resourcesthus reduced food intake for these women. The significant number of children in the household, coupled with the early marriage practices and the illiteracy of the women make them remain at home as housewives without any income generating activity. This is confirmed in Table 1 with 59% of the lactating women being housewives.This socio-economic context makes the women completely dependent on their husbands for all their householdneeds, food included. This has a considerable impact on the nutritional status of the lactating mother in particularand that of the household in general. Forty percent (40%) of the lactating mothers were overweight with a BMI between 25 and 29.9, and 9% were obese with a BMI of 30 and above. This expresses a situation of over-nutrition among the studied population, certainly due to the lack of physical activities as well as their physiologic status as lactating mothers which involves a change in food behaviorto cover the needs for breast-feeding which is practiced in the region.

Lactating mothers in Ngaoundere consume a lot of green leafy vegetables in their diet, which are rich in carotenoids. To a lesser extent, animal products like eggs and chicken with high vitamin A activity are also added in the meals during food preparation. These animal foods and vegetables are commonly consumed in association with cereals and tubers which are staple foods in the region. These foods are very rich in sugars, but are not good sources of carotenoids and vitamin A. Carotenoid content was highest in green leafy vegetables with values ranging from 27.56 mg in Hako Mbaï to81.59 mg in Eru. Variations were observed with the type of vegetable as well as the method of preparation.Some leafy vegetable are naturally richer in carotenoid than others, and is in the case of giligandja and folong which have high levels of carotenoids (Djuikwo *et al.,* 2011). For the same variety of vegetable, the type of ingredients added has a significant influence on the carotenoid content of the whole meal. For example, the same variety of vegetable prepared with tomatoes and carrots had higher carotenoid content than their counterparts cooked with groundnuts. Similar situation occurs with folong, zom and ndole.Tomatoes are a good source of *â*-carotene (Matthieu-Daudet *et al.,* 2001) and this explains the increase in carotenoid content of dishes cooked with these food ingredients. Groundnuts are poor in carotenoids and in addition could have a dilution effect on the quantities of carotenoids initially present in the vegetables.The use of palm oil which is a rich and good source of *â*-carotene (Matthieu-Daudet *et al.*, 2001) in the preparation of some dishes like eru, fried zom and koki equally improved their carotenoid content. These results are closer to those found in previous studies (Djuikwo *et al.*, 2011) which reported that ingredients added during preparation of meals containing leafy vegetables (oil tomato, carrot) enhanced their carotenoid content. Besides the type of vegetable and the method of preparation, the treatments applied to these vegetables could also influence their carotenoid content. Some authors demonstrated that treatments applied to vegetables such as solar drying, blanching in water or blanching with natron significantly reduced carotenoid content of dishes (Djuikwo *et al.*, 2011). Thus, a meal cooked directly with fresh raw vegetables should have a higher carotenoid content than a dish prepared with vegetables that have been previously treated. These findings were supported by the findings of this study. The three factors (species of vegetable, method of preparation and treatments applied)partly explains why the results obtained in this study are higher than those reported in Burkina-Faso (Kossiwavi*et al.,* 2003) for "Yinkum" (*Solanum nigrum*) and Baobab leaves (*Adansonia digitata*), but lower than those found by in Ivory Coast (Soro *et al.,* 2012) for "Morelle noire" (*S. nigrum*) *and* "Amarante" (*Amaranthushybridus*). In addition carotenoid analysis in this study was carried out on the cooked dishes while in Ivory Coast, *â*-carotene content was determined in the raw leaf samples (Soro *et al.,* 2012).

Lactating mothers in Ngaoundere consume on average 641.16 ± 88.99 µg of vitamin A per day, corresponding to 75.4% of the Recommended Daily Allowance. This suboptimal consumption of vitamin A exposes the lactating women and their babies to vitamin A deficiency and its complications like night blindness, anemia, lag of growth, weakness of immune system and even maternal and infant mortality. This level of coverage of vitamin A needs is higher than the 62% found in Burkina Faso (Kossiwavi *et al.*, 2003) where 150 households were sampled in a village of approximately 2000 inhabitants. This difference is explained at three levels: the sample population, site of the study and food habits. The study in Burkina Faso was done in a small village which is a rural setting where the population is exposed to malnutrition, as opposed to the present study where the population was both rural and urban. The sampled population in this study concerns only lactating mothers (0-4 months) who has as habits to increase their intake to cover for their needs and that of their babies, while the study in Burkina Faso was conducted using the entire households, that is father, mother, children, and even grandparents, cousins and nephews.The food habits, are closely linked to food availability and accessibility and extremely vary from one region to another.The level of coverage of 75.4% of vitamin A needs found in this study is also higher than the 67.4% reported by Ngaha *et al.* (2014) for pregnant women in Ngaoundere town and this could be due to the physiological state of the women. Most of the pregnant women in theafore mentioned study were in theirfirst trimester of pregnancy, corresponding to a period when the amounts of cooked foods consumed may be reduced due to bouts of nausea resulting from hormonal changes in their body (Wittenberg, 2012). In all the studies so far reported, these inadequate level of coverage of vitamin A attestto the high prevalence of VAD in Africa reported by WHO (2004). The high carotenoid content in the dishes containing green leafy vegetables (Table 2a) could let believe that their consumption would be enough to meet the Vitamin A requirements for these lactating mothers, but these values are based on dry weight. The real content of the cooked dishes may be revealed by their water content and the quantities actually consumed thus meeting their Vitamin A requirements become difficult.

The average daily consumption of sugar, fats, proteins and fibers by the women were respectively 280.79 g, 107.31 g, 59.67 g and 21.72 g corresponding respectively to 112.3%, 119.2%, 99.5% and 86.9% of the recommended daily intake for lactating mothers. The high consumption of oiland sugars exposes these women to overweight and obesity as presented in Table 1, but on the other hand, this high consumption of oil could assist absorption and bioconversion of *â*-carotene to vitamin A. Studies have shown that pure *â*-carotene dissolved in an oily dispersion was absorbed more efficiently (>50%) compared to carotenoids in raw fruits and vegetables like *â*-carotene of carrot or lycopene of tomato which were slightly absorbed (<3%) (Stahl and Sies, 1992). Added to that, to optimize the bioavailability of carotenoids, food oil have to be consumed during the same meal as absorption and bioconversion of *â*-carotene are significantly reduced in case of insufficient oil intake (Prince et Frisoli, 1993). Knowing that proteins are very important in Vitamin A metabolism and can equally contribute to enhancing the Vitamin A status of these women, a coverage of 99.5% of needs in proteins is good for Vitamin A absorption and transport within the body. Vitamin A is transported from liver to periphery organs by a specific protein in the blood, the Retinol Binding Proteins (Thurnham *et al.,* 2000), and the retinoic acid binds to albumin at the level of intestinal mucosa to be transported in the blood (Villamor *et al.,* 2002). Food fibers reduce the bioavailability of carotenoids by trapping them, or by interacting with biliary acids having as result increase in the fecal excretion of lipids and fat-soluble substances like carotenoids (Rock. and

Swendseid, 1992). Therefore, the low consumption of fibers by these women could be beneficial for pro-Vitamin A absorption. All these observations show that the primary causes, notably the low content of vitamin A in the dishes caused by availability and treatment are principally responsible of VAD risk among the women. Their macronutrients intake (sugars, oils, proteins and fibers) are not necessarily responsible for the poor VAD status of the womenas their intake were within the recommended levels.

Forty eight (48)% and 34% of the lactating mothers were at risk respectively of slight and acute VAD, implying that more than a quarter of these women had limited access to vitamin A rich foods. This rate is lower than that reported by Ngaha *et al.* (2014) for pregnant women (18-40 years) in Ngaoundere (Cameroon). This difference could be attributed to the physiologic state of the women. Besides the studies were carried out at different periods indicating a possible variations in seasons (Ngaha *et al.*, 2014). In the dry season in Ngaoundere food crops and vegetables are scarce and expensive on the market, and as such quantities consumed in the household are reduced. One could therefore think that lactating women in Ngaoundere are less expose to VAD than in Madagascar. A nutritional study on VAD in mothers (15-49 years) in Madagascar (Razafiarisoa, 2001) reported a prevalence of 29%, lower than 34% (acute VAD risk) found in the present study.This difference could be due to the diet that is significantly different from one country to another, as well as other factors like climate, soils, socio-economic conditions, nutritional behaviors and food patterns. In the Adamawa Region, consumption of liver and other animal products, red palm oil and carrots, which are very rich in Vitamin A and pro-Vitamin A, is low, due to the fact that they do not form part of the food habits of the population of that region.

CONCLUSION

This study reveals suboptimal dietary intake of vitamin A, insufficient to cover the needs of lactating women in Ngaoundere town, but a coverage of needs in proteins, fats and sugar, essential nutrients in absorption, bioconversion, transport and metabolism of carotenoids and vitamin A. The primary causes are principally responsible for VAD risk among these women that is insufficient intake from the diet. 34% of the lactating mothers were exposed to slight and acute VAD, thus nutritional intervention programs should be envisaged in this area to alleviate this situation taking into consideration their low literacy rate,socio-cultural practices and food habits of the population.

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