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Contribution of plant-based sauces to the vitamin A intake of young children in Benin

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ABSTRACT

A food consumption survey on 420 children was conducted in four areas in Benin to identify the local vitamin A (VA)-rich foods most frequently eaten and assess their contribution to the coverage of VA requirements of young children. Mangoes, eggs, red palm oil, various leafy vegetable (LV) sauces and palm nut juice sauce appeared to be the main VA-rich foods consumed. The recipes of the most promising sauces were characterised. Sauces with red palm oil/palm nut juice showed high carotenoid contents ranging from 0.9 ± 0.3 to 4.0 ± 0.8 mg Retinol Activity Equivalent/100 g dry matter (DM). Lipid contents were also high (from 39.6 to 66.8 g/100 g DM). When consumed, and taking into account the mean quantity eaten per meal, LV sauces containing red palm oil or palm nut juice contributed to the meeting of more than 70% of the recommended VA intake of young children.

1. Introduction

Vitamin A deficiency (VAD) is a major nutritional deficiency disorder in many developing countries. VAD especially affects young children, in whom it can cause xerophthalmia and lead to blindness, and can also limit growth, weaken innate and acquired host defenses, exacerbate infection and increase the risk of death (Sommer & West, 1996). These consequences are defined as VAD disorders (West, 2002). Worldwide, 127 million preschool children and seven million pregnant women are VA deficient. Approximately one out of three children suffering from VAD lives in sub-Saharan Africa (West, 2003). In Benin, this problem is responsible for 34% of infant mortality and affects 68% of children under 5 years of age (Ministère de la Santé Publique du Bénin (MSPB), 2004).

VA is a liposoluble vitamin present in some animal products in the form of preformed retinol and in plant foods in the form of carotenoids, several of which are precursors of retinol. In Western societies, animal products provide more than 70% of daily VA intake and the remainder (less than 30%) is provided by plant sources (Hennekens, Buring, & Peto, 1994). In contrast, in developing countries, fruit and vegetables provide 70–90% of total VA intake (FAO/WHO, 1998). Numerous vegetables with high carotenoid content are available and affordable in Benin as in many other developing countries. Moreover, it should be underlined that carotenoids, even when they have no provitamin A activity such as lutein and lycopene, have other health benefits. Recently, great interest has been focused on antioxidant activity of carotenoids, due to their ability to scavenge active oxygen species and free radicals formed during metabolism or encountered in the environment (pollution, ultraviolet, tabagism) (Kotíková, Lachman, Hejtmánková, & Hejtmánková, 2011). A high antioxidant dietary intake is associated with lower incidence of several diseases, especially cancers (Riboli & Norat, 2003). Hence, the identification of local carotenoid-rich foods deserves special attention.

As far as strategies to reduce VAD are concerned, the food-based approach is increasingly emphasised because it is sustainable, and adds variety to the diet, thus providing nutrients other than VA. One very important question is whether the consumption of plant-based sauces can significantly contribute to covering young children's VA requirements. Therefore, assessing the contribution of traditional LV sauces to fulfilling daily VA requirements is a major issue for the definition of relevant food-based strategies to combat VAD in vulnerable groups (Lin, Chien, Yang, & Cheng, 2007). Many studies have described a wide variety of LV consumed in Africa and highlighted their high provitamin A carotenoid content (Avallone, Tiemtore, Mouquet-Rivier, & Trèche, 2008; Delisle, Bakari, Gevry, Picard, & Ferland, 1997). Young children in sub-Saharan Africa eat cereal-based foods daily accompanied by

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a wide variety of sauces among which many are prepared with LV. In Benin, these green LV sauces sometimes include palm nut juice or red palm oil, which are also major sources of carotenoids. Provided they are eaten in sufficient quantities and quite frequently, these sauces can have a beneficial effect on health by supplying micronutrients (vitamins, minerals) or antioxidants (Avallone et al., 2008).

The term "sauces" covers a variety of liquid or semi-liquid dishes with many different ingredients including different vegetables, animal products and seasonings. In Africa (Cameroon, Burkina Faso and Madagascar), sauce recipes have already been collected including the list of ingredients used, preparation methods and nutrient contents (Gwanfogbe, Chambers, Martin, Fotso, & Smith, 1991; Avallone et al., 2008; Randrianatoandro, Avallone, Picq, Ralison, & Trèche, 2010). However, few studies have investigated the contribution of sauces to fulfilling the VA requirements of young children. In Tanzania, one study showed that provitamin A carotenoids from LV were a major dietary source of VA and contributed from 23% to 72% of the daily recommended intake of VA in children (Mulokozi, Hedrén, & Svanberg, 2004).

Another important issue related to dietary carotenoids is their bioconversion that depends on the characteristics of the food matrices and on their fat content (Tang, 2010; van het Hof, West, Weststrate, & Hautvast, 2000). Consequently, processing food can act in two ways. Firstly, under drastic thermal treatments or by leaching, it can affect total carotenoid retention by degradation. Secondly, it can improve the bioconversion of carotenoids to retinol, due to changes in food matrices such as fat incorporation. A recent study on the influence of different amounts of dietary fat on the bioavailability and bioconversion of provitamin A carotenoids in meals containing LV, showed that a minimum amount of fat (2.4 g fat/meal) is required to ensure the absorption of provitamin A carotenoids, and to improve VA status (Ribaya-Mercado et al., 2007; Tang, 2010; van het Hof et al., 2000).

The objective of this study was first to identify the VA-rich foods most frequently consumed by 6–35-month-old children through a food consumption survey based on weighed food records. The processing of the most promising VA-rich sauces was subsequently monitored in households, and final sauces and corresponding raw materials were sampled for the determination of their carotenoid contents to assess the contribution of plant-based sauces to the coverage of VA requirements of young children.

2. Materials and methods

2.1. Food consumption survey methodology

2.1.1. Processing and subjects sampling

A food consumption survey of 420 6–35-month-old-children was conducted in four areas (urban, rural) in Benin in 2009 to identify the main VA-rich foods eaten by children using the weighed food record method. As the aim of the study was to characterise potential VA-rich foods, children aged 24-35 months were included in the survey's sample in addition to the at-risk group of young children (6–23 months) in order to identify a larger range of traditional dishes.

Survey sites were non-randomly selected. The choice of the sites was intended to represent two different agro-ecological regions in Benin (North and South), assuming that foods available on markets differ in rural and urban areas (food diversity is considered to be higher in urban areas), the four survey sites were *Cotonou* (urban) and *Zè* (rural) in the South and *Natitingou* (urban) and *Boukoumbé* (rural) in the North. In each site, the sample comprised 105 children distributed in three age groups: 6–11, 12–23 and 24–35 months; in each age group, 35 subjects were randomly selected. Due to some missing or erroneous data, final data analyses were performed on 415 subjects of the original 420. The survey was carried out on three non-consecutive days. Every food item eaten by the children was systematically recorded by weighing the bowl or food itself before and after consumption throughout the day (from the time the child awakened until bedtime). Recipes of foods prepared in the household and eaten by children were carefully recorded and all ingredients were weighed using a kitchen scale (Seca; range 5000 g; precision 1 g). EpiData 3.1 was used for data entry, and EpiData Analysis (V2.2.0.167) and SPSS (16.0 for windows) were used for data analysis.

2.1.2. Follow-up of the preparation of traditional sauces and sampling

Sauces most frequently eaten by 6–35-month-old-children during the survey or that appeared to be useful for their potentially high micronutrient content (VA, zinc and iron) were selected for characterisation (Table 1). Their exact preparation was recorded in the South of Benin (*Cotonou* and *Zè*) during home visits to five different women, and the recipes were written down in detail. The types and quantities of ingredients and the chronology of each unit operation used to prepare each ingredient were recorded, along with the cooking temperature and time. At the end of preparation, two samples of final product were placed in tightly sealed plastic containers. One sample was freeze-dried and crushed before lipid and fibre analyses. The other sample was frozen (−20 °C) to determine carotenoid and retinol contents.

2.2. Biochemical analysis

2.2.1. DM content and pH measurement

DM contents were determined by oven drying at 105 °C to constant weight. The pH of the dishes was determined using a WTW 340i pH-metre (WTW, Weilheim, Germany).

Determination of lipid and fibre contents: Lipid content was determined with a HT6 Soxtec system (Tecator, Höganäs, Sweden) following the standard Soxhlet extraction procedure (AOAC, 2003). The Acid Detergent Fibre content (approximately cellulose and lignin contents), was determined using a Dosi-fibre (Selecta, Barcelona, Spain). Results were expressed in g per 100 g DM.

2.2.2. Determination of carotenoid and retinol content

Frozen samples (~0.5 g) were mixed in a glass tube with 10 ml of ethanol/hexane 4/3 (v/v) for 5 min (Taungbodhitham, Jones,

Table 1
Beninese, English and scientific names of Beninese sauces based on leafy vegetable, okra or palm nut.

	Sauce	Main ingredient	
	Beninese name[a]	English name	Scientific name
Leafy vegetable (LV)	*Amanvivè*	Bitter-leaf	*Vernonia amygdalina (Delile)*
	Fotètè	Amaranth	*Amaranthus cruentus (L.)*
	Fingninman	Cassava	*Manihot esculenta (Crantz)*
	Fonman	Black plum	*Vitex doniana (Sweet)*
	Gboman	African eggplant	*Solanum macrocarpon (L.)*
	Soman	Cockscomb	*Celosia argentea (L.)*
Palm nut	*Dénoussounou*[b]	Red palm nut	*Elaeis guineensis (Jacq.)*
Vegetable	*Févi*	Okra fruit	*Hibiscus esculentus (L.)*

[a] Language of the main ethnic group "*Fon*".
[b] Sauce based on palm nut juice sometimes with leafy vegetables added (*Dénoussounou*-LV).