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RESEARCH ARTICLE

NUTRITIONAL QUALITY AND WEIGHT EVALUATION OF A DIET BASED ON *IRVINGIA GABONESIS* (IRVINGIACEAE) CONSUMED BY THE PEOPLE OF DALOA, WEST-CENTRAL OF CÔTE D'IVOIRE: INFLUENCE ON YOUNG RATS GROWING (WISTAR)

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ABSTRACT

The almonds of (*Irvingia gabonesis*) "Siako" in the Betes or "pkle" among the Gueres are used in food of the people of the West of Ivory Coast. The sauce from these almonds is an accompaniment for typical dishes. Unfortunately these spontaneous food plants are less and less present in our markets given the excessive deforestation. In order to valorize these almonds and to encourage the domestication of the plant, we are interested in the determination of the essential constituents of these almond found in our main markets in Daloa (Central-West of Côte d'Ivoire).The results obtained after chemical analysis give nutrient contents respectively: 36,82 ± 0,26; 14,56 ± 0,26; 6, 62 ± 0,71; 13,85 ± 0,16; 13,30±5,20; 10,21±4,20; 12,69 ±3,14 and 21,41 ± 2,5%. In addition, biometric and physiological studies with rats (Wistar) revealed steady weight gain after the sixth day. This weight gain confirms the good quality of this spontaneous food plant. This suggests the popularization of this plant in the dietary practice of our populations and level with the well being of these.

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INTRODUCTION

In Africa, the survival of 30 to 80 percent of the poor depends directly on natural resources (Betti *et al.,* 2016). Plants have generally been the mainstay of the diets of African people (Kubmarawa, 2009).These people have a long tradition in using these wild plants as a dietary supplement in the making of their various typical foods (Chweya and Eyzaguire, 1999). Among these species *Irvingia gabonensis* belonging to the family of (Irvingiaceae). They are consumed by certain populations of forest regions. They are rich in essential nutrients (carbohydrates, proteins, lipids) and minerals that are important nutritional supplements in the diet of the mostly rural Ivorian people (Oulai *et al.,* 2014). These spontaneous food plants also have many virtues in the maintenance and prevention of many nutritional diseases because they contain many ingredients that help the growth and maintenance of the body (antioxidants) (Falade *et al.,* 2003). But forest remains a reservoir of natural wealth (fauna, flora, biosphere) (Kouamé *et al.,* 2008) .Unfortunately, in region of Upper Sassandra (Daloa), many hectares of forest are transformed into plantations. But the forest remains a reservoir of natural wealth (fauna, flora, biosphere) (Kouamé *et al.,* 2008) .This intense transformation of forest cover and uncontrolled urbanization pose the problem of the survival of our spontaneous food plants. In the past, these species have played an important role in the well-being of populations (Gautier, 1992). In addition, despite the abundance of many food products and changes in dietary habits, there is an upsurge in many no communicable and disabling diseases such as diabetes, hypertension, cancer, cardiovascular diseases and so on. (N'dong *et al.,* 2007, Apema *et al.,* 2010). African forests, especially Ivorian forests in particular, contain extraordinary food potential, their nutritional knowledge could prove useful in the face of the factors of impoverishment of our populations (Kouamé *et al.,* 2015). Unfortunately, little research is done on non-timber forest plants in general for the benefit of cultivated plants. Alternative strategy research is needed to strengthen the nutritional status of rural and urban populations, an essential link in development (Dally *et al.,* 2014). This study aims to determine nutritional quality of *Irvingia gabonesis* diet showing on the weight of the fed rats.

MATERIALS AND METHODS

Equipment

Field of study (Daloa)

Location: Daloa is located in the center-west of Côte d'Ivoire in the region of Upper Sassandra. It is bathed on its western

flank by the upper course of the Sassandra River from which it derives its name (the upper Sassandra) which covers an area of 15205 km² with a population estimated at 1 534 100 inhabitants (INS, 2014).

The region of Upper Sassandra is limited as follows:

- In the north, region of Worodougou (Seguela) and Bere (Mankono);
- To the east, region of Marahoue (Bouafle);
- In the south, region of Gôh (Gagnoa) and Nawa (Soubre);
- In the west, region of Tonkpi (Man) and Guemon (Duekoue).

Daloa is the chief town of Upper Sassandra region. It is located 383 km from the city of Abidjan and 141 km from Yamoussoukro. With an area of 530.5 hectares or 5,305 km². The Department of Daloa occupies 28% of the surface area of Haut-Sassandra. It is made up of six sub-prefectures (Daloa, Bédiala, Gadouan, Gboguhé, Gonate and Zaïbo).

The Department of Daloa is limited:

- In the North by departments of Vavoua;
- In the South by department of Issia;
- In the West by department of Zoukougbeu.
- Our study took place on local markets (LOBIA, ORLY, GRAND MARCHE).

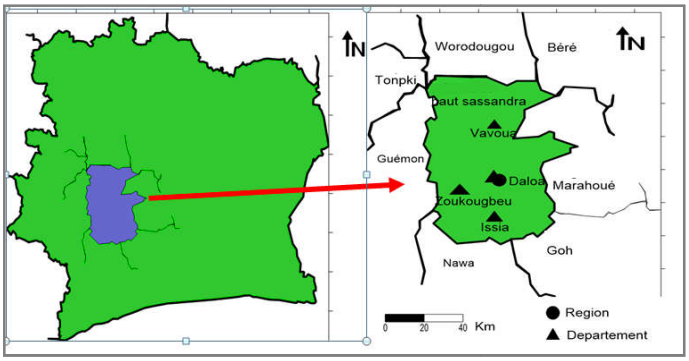


Figure 1. Location of Daloa

Climate:
Region of Upper Sassandra in which the city of Daloa is located belongs to the humid tropical climate. It is for this reason that the city of Daloa is very humid with a four-season climate including the big rainy season complicated by the inter-season and marked by thunderstorms (April to mid-July), the small dry season (mid-July mid-September), the short rainy season (mid-September to November) and the long dry season (December to March) (Kouamé et *al*., 1998).

Vegetation and terrestrial flora: Daloa Department is a forest area. Soils are of the ferralitic type. There is a classified forest (Haut Sassandra classified forest) located in semi-deciduous dense forest zone located between 6 ° 52 'and 7 ° 24' north latitude, 6 ° 59 'and 7 ° 10' west longitude. It is bounded on the west by the Sassandra River and covers an area of 102,400 ha. Agricultural activities and bush fires have severely degraded this vegetation in recent years, there is savanization of the region of Upper Sassandra (Daloa) (SODEFOR, 1994).

Pluviometry: Rainfall of the Daloa Department oscillating between 1200 and 1600 millimeters of rainfall per year. Rainfall is spread over the whole year with a maximum in June and July and a minimum from December to March. Humidity is important with an average annual average temperature of 26 ° C (SODEXAM, 2010).

Population and economic activities: Population of the municipality of Daloa is estimated at 319487 inhabitants (INS, 2014) and is the third most populous city in Côte d'Ivoire. The population is cosmopolitan and made up of autochthonous ethnic groups (Betes, Gouros, Gueres and Nianbouas), allochtones (Baoules, Malinkes, Senoufos, Agnis, Atties, etc.). The foreigners are mainly nationals from ECOWAS (Burkinabe, Malians, Ghanaians, etc.). The economic activities of the population are dominated by trade and the agricultural sector. Non-native and non-native speakers from other localities are the most involved in this sector.

Fresh fruit photography **Dry almonds photography**

Figure 2. *Irvingia gabonensis* (Irvingiaceae)

METHODS

Chemical analysis: The recommended methods of analytical association chemists (AOAC, 1990; AOAC, 1998) were used to determine moisture levels, ash, crude protein and raw fat. Moisture content was determined by heating 2 grams of constant weight samples in a furnace crucible (MMM Medcenter Gmbh (D-82152, Munich, Germany) maintained at 105° C for 4 hours. Ash was determined by incineration of 1 g samples placed in a muffle furnace (P Selecta, Spain) maintained at 550 ° C for 6 hours. Crude protein content (% total nitrogen × 6.25) was determined by the Khedjahl method (Tchachambe *et al.,* 2017) using 1 g samples.The crude fat was obtained by exhaustively extracting 5 g of each sample in a Soxhlet apparatus for 8 hours using hexane as the extractant (Enzonga-yoka *et al.,* 2011). Total carbohydrate (%) was estimated by difference as showing in the equation:

Total Carbohydrates (%) = 100 - [Proteins (%) + Fat (%) + Asch (%) + Fiber (%)].

Analysis of minerals: Minerals were extracted from the ashes by adding 20 ml of 2.5% HCl, heated in a steam bath to reduce the volume to about 7 ml, and this was quantitatively transferred to 50 ml of volumetric flask. It was diluted to volume (50 ml) with deionized water, stored in clean polyethylene bottles, and the mineral contents were determined using a spectrophotometric absorption atom (Perkin-Elmer, Model 2380, USA). One grams of powdered sample were ashed 550°C for 12h in a muffle fumace. If ashing was incomplete, concentrated nitic acid (several drops) was added and the samples re-ashed for a further 6h at 550°C. The ashed

sample were disolved in 6N HCL (5ml) with de-ionized water. The concentrations of iron, zinc, magnesium contents were dimermined in aliquots by Flame. Atomic Absorption Spectrometry (ACTIUNICAM 929 serie GE 4999190)b (Bogmis *et al.,* 2018). For the determination of calcium, lathanum (1%V/V) was added to both standarts and samples to suppress interference from phosphorus. Replicates of fod composites were analyzed to check on the homogeneity of portion sample from food and reproductibility of method. The accuracy of the method was dimermined based on the recommandations of the National Bureau of Standar (NBS, Nigeria Ochard Leaves Standard, Reference Material N° 1571).

Animal experimentation

Alimentation: Different diets were, at the time of distribution, reconstituted in pellets by means of a certain quantity of water in order to minimize wastage and in grains for the control food. Quantities of fresh food are weighed before being served. The dry matter of the fresh food, served in the form of pellet is administered ad libitum to the animals, Every two days the animals are weighed, before making a new distribution. Moreover, clean tap water is served to animals and renewed daily. The experiment was carried out with young growing rats aged 37±1 days. The manipulation lasted 10 days including 2 days of adaptation.

Biometric (physiological study): The weight and height evolution of young rats. The observation of offspring has been daily from birth. Weaning is done on the 21st day. The main parameter taken into account is mainly the weight according to the method of N'diolene (2006). Animals of 37±1 days were weighed at the beginning of the experimental period and then at two-day intervals until the end of the experimental period. Growth, translated by weight gain (GP), is obtained by the difference between the final weight and the initial weight it is expressed in g/d (Dally *et al.,* 2014).

GP (g/d)=(Final weight-initial weight)/number of days

Statistical analysis

All the analyses were performed in triplicate and data were analysed using EXCELL and STATISTICA 7.1 (StatSoft). Values were expressed as mean ± standard deviation (SD).

RESULTS AND DISCUSSION

Nutrients g/100g DM Minerals mg/100g DM

Table 1. Chemical composition of almonds of *Irvingia gabonensis*

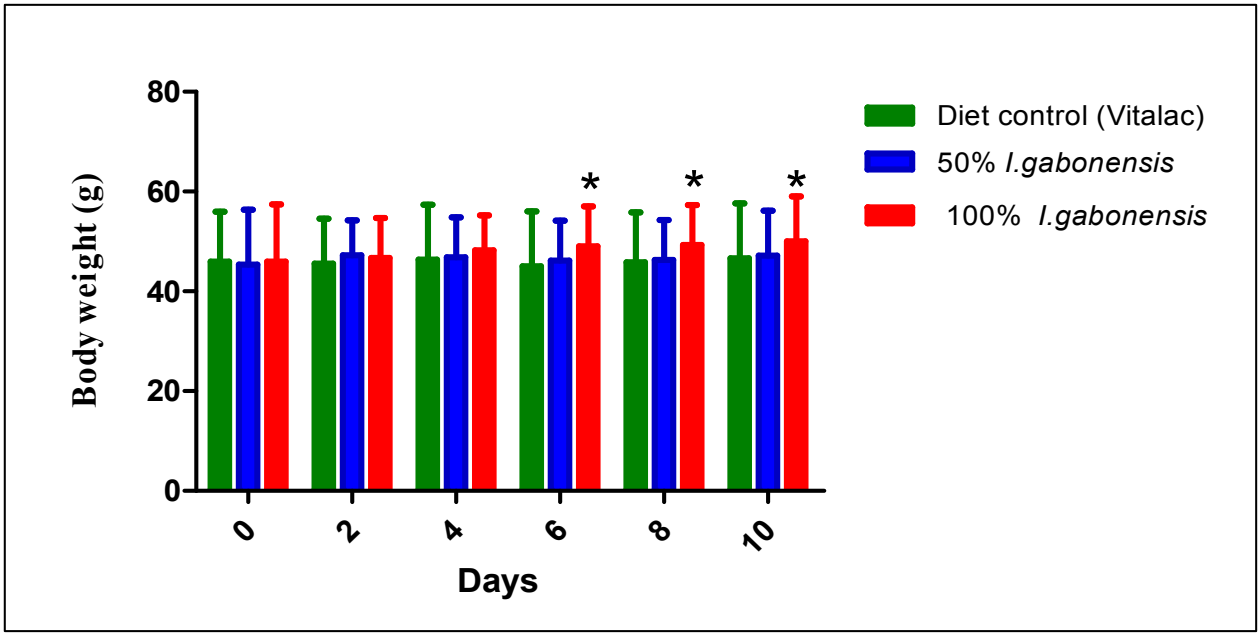
	Nutrients g/100g MS					Minérals mg/100g MS			
	Dry matter	Carhohydrates	protéins	lipids	fiberss	Ca	Mg	Fer	Zn
Moyenne	94,6 1±1,2^{e}	36,82±0,26^{a}	14,56±0,26^{c}	6,62±0,71^{d}	13,85±0,16^{b}	13,30±5,20^{a}	10,21±4,20^{c}	12,69±3,14^{b}	21,41±2,5^{d}

Values are means ±SE for five déterminations. Means with differents letters in a column within each independent variable are significantly different (p<0, 05)

Table 2. Variation in weight gain of young rats over 10 days of experiments

Days	Control	Lot 50 % *I. garbonensis* +CF	Lot 100 % *I. gabonensis*
0	45,96±10	45,38±11	45,95±11,50
2	45,55±9	47,20±7	46,68±8
4	46, 35±11	46,85±8	48,22±7
6	45,02±10	46,19±8	49,01±8*
8	45,83±11	46,27±8	49,30±8*
10	46,65±11	47,19±9	50,00±9*

*: Significant increase from the 6th day; CT: Carbohydrate food



*: Significant increase from the 6th day

DISCUSSION

Protein levels obtained on almond *Irvingia gabonensis* (Irvingiaceae) are around 14,5%. This value is higher than that obtained on some non-woody wild plants such as *Blighia sapida* (Sapindaceae) (11,99%) consumed by the northern peoples (Ouattara *et al.,* 2010, FAO, 1999) have shown that suns contribute to a large extent to the alteration of certain proteins. Indeed, proteins remain the major source of amino acids and play role in organoleptic properties (Akinhanmi *et al.,* 2008). Protein value obtained on the *Irvingia gabonensis* kernel (Irvingiaceae) remains identical to the recommended value for a meal ($P < 0.05$) according to (FAO, 2003). Indeed, FAO's recommendations range from 12% to 15%. In addition, it should be noted that this value remains very high compared to many other edible plants that are sold on our markets (*Hoslun diaopposita* (Lamiaceae), *Isoberli niadoka* (Caesalpiniaceae), *Justicia secunda* (Acantahaceae) etc. Carbohydrate levels remain high at 36,61% compared with many other spontaneous plants including *Blighia sapida* aril (Sapindaceae) with carbohydrate content of 43% (Ouattara *et al.,* 2010). It is recognized that carbohydrates and lipids are the main sources of energy in the body (Remesy, 2001). Lipids, on the other hand, are very low at 6,62% compared with many food plants with higher levels, such as aril *Blighia sapida* (Sapindaceae) with 45,32% and peanut seeds of *Arachis hypogeae* (Fabaceae) with a lipid content of 45% according to (FAO, 2000). Lipids contribute enormously to the absorption of fat-soluble vitamins so they remain important for the meal. However, their excess is to be avoided. Indeed, some oils contain a high content of polyunsaturated fatty acids which is beneficial for the control of cholesterolemia and protection against cardiovascular diseases (Azibuo *et al.,* 2008). Fibers are well represented with 19,85%. This value is much higher than that of many exotic food plants such as potato 13,34%, food leaves 6,70% and yam 5,67% (Sop *et al.,* 2008). Indeed, the fibers are neither digested nor absorbed in the small intestine.

They contribute to the production of stools, the stimulation of colonic fermentation, the reduction of fasting cholesterol, the reduction of blood glucose or postprandial insulinemia. Thus, the fibers protect the body against bowel cancer, diabetes and cardiovascular diseases (Ponka *et al.,* 2005). They also facilitate cellular hydration (AFASS, 2002). Minerals represent 4% of the total mass of an individual, constituents of enzymes, hormones and vitamins, they contribute to the structure of bones and teeth and are associated with heart rhythm, muscle contraction, nerve conduction and the water balance and acid-base of the body. The mineral composition of *Irvingia gabonensis* kernel (Irvingiaceae) gives the following values in mg/100g. The magnesium content of this food is around 20,21%. Plant products could have the same content as cashew with 19,3% (Akinahnmi *et al.,* 2008). In fact, magnesium is recognized in the maintenance of the electrical potential of the nerves and the activation of the enzymatic system and in the membrane stabilization as well as the regulation of the transmission of nerve impulses in the nervous system (Aremu *et al.,* 2006). This same author obtained for the plant product 21,5% calcium against 13,3% in the almond *Irvingia gabonensis* (Irvingiaceae) in the previous study. Calcium plays an important role in ossification and prevents long-term osteosclerosis that often afflicts the elderly (Dansou *et al.,* 2000). Zinc and iron are well represented respectively with 21,41% and 12,69%. These values are appreciable for the good functioning of the organism. Biometric study of animal weight fed after 10 days of treatment showed better disposition for weight gain in all fed rats. After ten days of feeding, *Irvingia gabonensis* (Irvingiaceae) fed rats had a greater weight (8,81%) than those fed the 50% (3,98%) diets and the control diet. This weight gain could be explained by the presence of the protein nutrients contained in the kernel of this plant. Indeed, studies conducted by (Trèche *et al.,* 1993) showed a steady development of cell metabolism with synthesis of the clean material in young rats and the weight gain of these fed protein reference diets. Authors like (Bouafou *et al.,* 2007); (Méité *et al.,* 2008) have clearly confirmed the interest of a protein diet administered to rats. Evolution of weight of the rats over the ten days as a function of time materializes more precisely the physiological and weight states of these growing rats and we can deduce the qualitative aspects of this diet. *Irvingia gabonensis* (Irvingiaceae) based diet provides guidance on the choice of the combination of a dish to serve in order to overcome the deficiency that plant-based diets might cause to exotic products. In particular, all these condiments that are found in quantity in our markets and which are derived from many phytosanitary treatments. We can therefore conclude in this study that sauces made from *Irvingia gabonensis* (Irvingiaceae) would benefit from being popularized. Given its impact in this experimental study performed on Wistar rats to provide a reliable and much more exhaustive and scientific database. Investigation in the large field of wild nutritional plants (spontaneous food plants) as part of the fight against malnutrition (physiological disorder) that persists in our societies as (rural, urban and peri-urban). Finally, the export and study of new diets to help better understand the etiology of the many diseases that our populations are regularly confronted with.

Conclusion

The present study notes a low presence of spontaneous food plants in general compared to cultivated (exotic) plants in our various markets in the Center-West of Côte d 'Ivoire. In addition, the analysis of the *Irvingia gabonensis* (Irvingiaceae) samples obtained shows well-represented nutrient values. Especially the proteins (14,56±0,26%), the fibers (13,82±0,16%), and the carbohydrates (36,82±0,26%) which have a great nutritional interest and contribute to the maintenance of the health. In addition to a low lipid content (6,62±0,71%) which would consolidate pathologies due to lipids. Calcium mineral (13,30±5,20%), magnesium (10,21 ± 4,20%), iron (12,69±3,14%) and zinc (21,41±2,5) %) cofactors who also have a fundamental role in the maintenance of the body. To address the health concerns of our populations, exploration of these spontaneous food plants has been necessary. Biometry study carried out indicates globally that this diet has good provisions on the growth of young rats fed thus confirming the good quality of this food. This spontaneous plants would benefit from being promoted in food practices in order to help the well-being of our contemporaries.

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