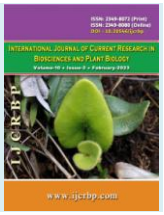
International Journal of Current Research in
Biosciences and Plant Biology

Volume **10** • Number **2** (February-2023) • ISSN: 2349-8080 (Online)

Journal homepage: www.ijcrbp.com



Original Research Article **doi:** https://doi.org/10.20546/ijcrbp.2023.1002.002

Main determinants of the fruits consumed by diabetic patients managed at the Antidiabetic Center of Abidjan (Côte d'Ivoire)

Béda Frank YAPO[1]*, Ginette Gladys DOUE[2], Jean-Brice GBAKAYORO[1], Patrick Aubin DAKIA[1], Kouakou BROU[1]

[1]Nutrition and Food Safety Laboratory, UFR of Food Science and Technology, NANGUI ABROGOUA University, Abidjan, Côte d'Ivoire
[2]Laboratory of Biotechnology, Agriculture and Valorization of Biological Resources, UFR Biosciences, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

*Corresponding author; e-mail: yapobedafranck@gmail.com

Article Info

Keywords:
Côte d'Ivoire
Diabetic patients
Dietary fiber
Fruit consumption
Sweet taste

Abstract

Fruit, commonly eaten raw, contains contain some nutrients good for diabetics health. Since most fruits taste sweet, it was interesting to investigate the dietary behaviour of diabetics towards fruits in the main diabetic center in Abidjan, Côte d'Ivoire. Of a total of 846 patients surveyed of the antidiabetic center in Abidjan, 73.3% awared of the health benefits of fruit for diabetics. 48.5%, awared fruit contained free sugar considered harmful for them. Regarding frequency and fruit, 29.8% of them consumed at least one fruit one or two days and 62.2% preferred to consume whole fruits rather than fruit juices (9.7%) while almost half (44.6%) consumed them much more after the meal. As for their amount, the majority of respondents consumed an average of 1 (20.57%) or 2 (69.50%) pieces of fruit at each intake and paid attention to their degree of ripeness (58%). The most consumed fruits were orange (61.5%), apple (57.4%), sweet banana (46.1%), papaya (39.6%), and mango (29.6%), contained between 2.21 and 9.02% total free sugars and between 0.52 and 1.33% total fiber. A large proportion of diabetic patients regularly consumed them at ripe (37.1%) or very ripe (32.7%) stage, ingesting a significant amount of fast sugar. Fruit consumption should be promoted to diabetics to enable them making more healthy choices.

• *Received: 10 December 2022* • *Revised: 27 January 2023* • *Accepted: 30 January 2023* • *Published Online: 6 February 2023*

Introduction

Diabetes is a metabolic disorder characterized by chronic hyperglycemia resulting from a defect in insulin secretion and/or action (DeFronzo et al., 2015, ADA, 2022). Diabetes, in all its forms, has become one of the most prevalent non-communicable diseases in the world, jeopardizing the well-being of men and women worldwide (IDF, 2019). Globally, more than 1 in 10 adults are now living with diabetes (IDF, 2021). The global prevalence of this metabolic disorder is steadily increasing and the International Diabetes Federation (IFD) has estimated that 783 million adults (12.2%) would have diabetes by 2045, making it a leading cause of disability and death worldwide (IDF, 2021).

Côte d'Ivoire is not exempt from this real public health problem. According to the IFD, the prevalence of diabetes in this country increased from 4% in 2007 to 5.6% in 2014 and would have risen to 6.2% in 2017 according to the National Programme for the Control of Metabolic Diseases and Prevention of Non-Communicable Diseases (PNLMM/ PMNT) of Côte d'Ivoire.

To promote the restoration of a normal metabolism and the control of this process, dietary measures have remained one of the effective pillars of the management of diabetes mellitus (Strand, 2004; Osei-Yeboah et al., 2019) through the adoption of a balanced diet and regular physical activity (Frier, 2004). In addition, the consumption of sugars present in the various foods must be controlled, and it is known that anything that slows down their digestive absorption improves the glycemic index. Thus, dietary fiber has been considered not only a key element in the management of the diabetic patient but also in a healthy diet (Gurukar et al., 2013; Dreher, 2018).

In view of the above, a high consumption of fruits and vegetables would be associated with a decreased risk of developing type II diabetes (Mamluk et al., 2017; Rejman et al., 2021), stabilization of blood glucose levels, and prevention of cardiovascular disease (He et al., 2007; Aune et al., 2017). This benefit is due to their richness in vitamins, minerals, dietary fiber, phytochemicals, and free sugar (Gao et al., 2021). However, the sweetness of fruit in particular (Vincente et al., 2014; Rejman et al., 2021) makes it a food for which many diabetics have a lot of reserve regarding its consumption. Thus, they prefer to avoid their consumption in order not to induce hyperglycemia detrimental in the short term to the balance of blood glucose and in the long term, to the balance of all metabolic parameters. Therefore, a number of precautions should be taken by them.

Among these precautions, we can mention the choice of the type of fruit, the frequency of fruit consumption, the quantity of fruit consumed, the form of the fruit (whole or in the form of fruit juice), the degree of ripeness and the time of consumption (before, during or after the meal), etc. The general objective of this work was to identify the main determinants of fruit consumption by diabetic patients. To this end, a survey on fruit consumption was conducted among diabetic patients treated at the CADA (Abidjan Antidiabetic Center) and the total free sugar and crude fiber contents of the most consumed fruits were determined.

Materials and methods

Biological material

The biological material consisted of five (5) fruits including four locally produced fruits, namely orange (*Citrus sinensis* L.), sweet banana (*Musa paradisiacal* L.), mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), and one (1) imported fruit, apple fruit (*Malus domestica*). These fruits were purchased fresh at different stages of ripening at the market of the fruit terminal of the autonomous port of Abidjan and immediately transported to the Biotechnology Laboratory (UFR Biosciences) of the University Félix Houphouët-Boigny the same day in refrigerated coolers.

Methods

Food consumption survey

Type and period of study: This is a cross-sectional study with descriptive and analytical purposes that took place from February 14 to June 14, 2022.

Study site and population surveyed: This study took place at the Abidjan Diabetes Center (CADA) located within the National Institute of Public Health (INSP), in the commune of Adjamé, Abidjan. It focused on diabetic patients of all types, of all ages, male and female, who were regularly registered in the CADA files for treatment. This center was chosen as the setting for the investigation because of the large number of patients it sees on a daily basis (an average of 100 patients per day) and its experience in treating diabetics. Two things that make this center specialized in outpatient care and day care, a reference center in Côte d'Ivoire.

Conduct of the survey

The interview took place in the waiting room where patients were waiting to be seen by the specialist doctors. Patients were interviewed in turn before their consultation until there were no more patients in the room. Any patient who had already been seen by a health care worker, who had been advised to eat fruit and who agreed to answer our questions, was included in the study. Excluded from the study were any patients who had never been consulted by a health care staff, who had not received advice on fruit consumption, and those who were not available to answer our questions.

Data collection

Data were collected using a direct interview questionnaire. It consisted mainly of data on age, gender, health personnel that the diabetic patient consults and data related to fruit consumption (type of fruit consumed, frequency of consumption, knowledge about the nutritional benefits of fruit, time of consumption of fruit and the ripening stage of fruit). Fruit ripening stage was assessed by patients, based on images presented at different ripening stages for each fruit, to designate the preferred stage of fruit consumption by diabetic patients (early ripening, advanced ripening or very advanced ripening).

Nutritive value of the studied fruits

For this purpose, crude fiber and total free sugar, main fruits micronutrients were was evaluated.

Crude fiber content determination

The fiber content was determined according to the method of (AOAC, 1990). Ten (10) grams of sample (Me) was homogenized in 50 mL of sulfuric acid (0.25 N). The mixture was boiled for 30 min under reflux refrigerator. Then 50 mL of 0.31 N sodium hydroxide was added to the flask contents and boiled once more for 30 min under reflux refrigeration. The extract obtained after boiling was filtered through Whatman No. 4 filter paper and the residue was washed several times with boiling water (100 °C) until complete removal of alkali. The residue was dried in an oven at 110°C for 8 h. It was cooled in a desiccator and then weighed (M1). The residue obtained was incinerated in an oven at 550°C for 3 h, cooled in a desiccator, and then the ash was weighed (M2). The fiber content is given by the following equation:

$$\text{Crude fiber (\%)} = \frac{(M_1 - M_2)}{M_e} \times 100$$

Total free sugar content determination

The determination of total free sugars was done according to the phenol-sulfuric method as described by Dubois et al. (1956) after ethanosoluble extraction performed from the method described by Agbo et al. (1985). 0.5 g of the fruit powder were added and mixed with 10 mL of H_2SO_4 (1.5 N). After incubation in a boiling water bath (100 °C) for 15 min and cooling to room temperature, 10 mL of 70% ethanol, 0.5 mL of $ZnSO_4$ and 0.5 mL of potassium ferrocyanide were added. The whole mixture was homogenized, filtered throug whatman paper and the content of filtered was made up to 50 mL with distilled water in a 50 mL flask to constitue the sugar extract. For their quantification, 0.5 mL of this extract was introduced into a test tube and 1.5 mL of distilled water, 1 mL of aqueous phenol and 5 mL of H_2SO_4 were added successivly. The tube was placed in the dark for 10 min and absorbance was read with a UV-vis spectrophotometer (UV-1800, Pioway, China) at 490 nm against a blank. A standard curve was established from glucose solution (1 mg/mL), to determine the amount of total sugar in the sample (g per 100g of dry weight).

Statistical analysis

The survey data were input and processed with IBM SPSS Statistics 20.0 data processing software (IBM Corporation, SPSS Inc, Chicago, USA) and transferred to Excel. Descriptive statistical methods (frequency, mean, standard deviation) were used for quantitative and qualitative variables. Data from the biochemistry analysis were evaluated by the one-way ANOVA method followed by Tukey's multiple comparison test at the 5% level to see if the observed differences were statistically significant or not. All values were presented as mean ± standard deviation (standard error).

Results

A total of 846 diabetic patients followed at the INSP's Antidiabetic Centre were surveyed.

Socio-demographic characteristics of diabetic patients and health professionals consulted

Table 1 shows the age and sex of the patients interviewed as well as the category of health personnel that diabetics consult. The table shows that the female population constituted more than half of the patients surveyed, i.e. 64.78 % (548 patients), compared with 35.22 % for men (298 patients). Most of the diabetics surveyed, 44.33% (375 patients), were between 50 and 65 years old, and 26.24% (222 patients) were [35-50]. On the other hand, 17.26% (146 patients) were aged 65 and over, 7.45% (63 patients) were aged 18-35 and only 4.73% (40 patients) were under 18 years old. With regard to the CADA health personnel that the

diabetic patients consulted, 55% of the patients consulted doctors, while the remaining 45% were cared for by dieticians (28.5%) and nurses (16.5%) (Table 1).

Table 1. Age and sex of patients interviewed and category of health personnel consulting them (n = 846), INSP Abidjan

Parameters		Response	Percentage %
Sex	Male	298	35,2
	Female	548	64,8
Age (years old)	<18	40	4,7
	[18-35]	63	7,4
	[35-50]	222	26,2
	[50-65]	375	44,3
	> 65	146	17,3
Health personnel consulted	Doctor	465	55,0
	Nurse	140	16,5
	Dietician	241	28,5

Table 2. Determinants of fruit consumption by diabetics surveyed.

Parameters	Response	Percentage (%)
Knowledge about the importance of fruit in the diabetic diet		
Yes	620	73,3
No	226	26,7
Nutritional information on fruits		
Sugar	410	48,5
Vitamin	116	13,7
Fiber	83	9,8
No information	237	28,0
Frequency of fruits consumption by patients		
At least 1 fruit every 1-2 days	252	29,8
At least 1 piece of fruit every 3 to 4 days	153	18,1
At least 1 fruit every 5 days or more	148	17,5
No fruit	293	34,6
Preference of the shape of the fruits consumed		
Whole fruit	526	62,2
Fruit juice	82	9,7
None	238	28,1
Time of consumption of fruit		
Before the meal	142	16,8
During the meal	42	5,0
After the meal	377	44,6
Outside of mealtime	251	29,7
None	34	4,0
Number of fruits consumed per intake per diabetic patient		
1	174	20,57
2	588	69,50
3	62	7,33
4	13	1,54
> 4	09	1,06
Monitoring of ripening level		
Yes	491	58
No	355	42
Preference of ripening level		
Not ripe	50	05,9
Medium Ripe	66	07,8
Mature	314	37,1
Very ripe	277	32,7
No preference	139	16,4

Knowledge of fruit consumed by diabetic patients at the CADA

Identification of fruits most consumed by CADA diabetic patients

Fig. 1 highlighted the fruits effectively consumed by diabetic patients. In the basis of this figure, the fruits most consumed by the patients were both locally produced such orange (61.5%), sweet banana (46.1%), papaya (39.6%), mango (29.6%) and imported such apple fruit (57.4%), while the other fruits among which we have (tangerine, grapefruit, strawberry, grape, guava, pear, watermelon, kiwi, pineapple, avocado, lemon), were the least consumed (8.45%) by diabetic patients.

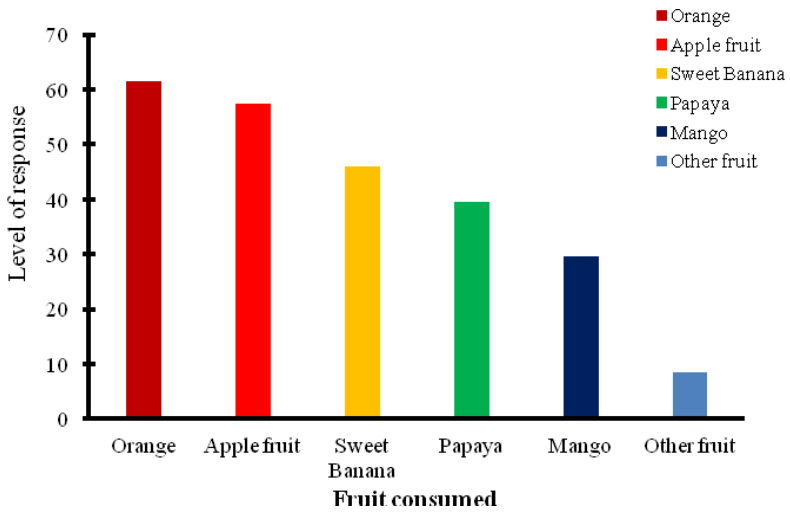


Fig. 1: Types of fruit consumed by diabetics surveyed.

Frequency of consumption and characteristics of fruit consumed by diabetic patients surveyed

Table 2 focused on the main determinants of fruit consumption by the diabetic patients surveyed, including the level of knowledge about the importance of fruit for diabetics and their fruit consumption habits.

Concerning the first determinant related to the level of knowledge about the importance of fruit (importance and nutritional value of fruit) for diabetics, the survey showed that a large proportion of the patients (73.3%) were aware of the importance of fruit in diabetic diet.

Among them, many more knew that fruit was rich in sugar (48.5%), vitamins (13.9%) and fibre (9.8%). However, concerning the second determinant relating to alimentary habits, several aspects were mentioned. First of all, the majority of diabetic patients reported consuming very little fruit. In fact, There were 34.6% who hardly ever consumed fruit. Among those who often consumed fruit, the rate of consumption was not sustained, with 17.5% saying they only ate fruit every 5 days or more, compared with 18.1% who ate fruit every 3 to 4 days. On the other hand, 29.8% of respondents had a more regular consumption pattern, eating a piece of fruit every 1 to 2 days. Regarding the mode of consumption, these patients say they prefer to consume the whole fruit (62.2%) rather than fruit juice (9.7%). On the other hand, 28.1% of them said they had no preference between these two forms of fruit consumption.

When paying attention to the timing of fruit consumption during the day, we found that almost half of the patients surveyed (44.6%) reported consuming a lot more fruit after meals compared to 27.7% outside of meals. When we look at the number of fruits consumed by these patients and their degree of ripeness, we see that the majority of respondents consumed on average 1 (20.57%) or 2 (69.50%) fruits at each intake and payed attention to the degree of ripeness of the fruits (58%) before consuming them. In this regard, we note that fruit is consumed much more at the ripe (37.1%) or very ripe (32.7%) stage (Table 2).

Fiber and sugar contents of the consumed fruits

Fiber and sugar content of fruits at the two stages of ripeness when most consumed by the diabetic patients surveyed are depicted in Table 3.

Table 3. Crude fibre and total free sugar content of the most common fruits consumed by diabetics at the ripe and very ripe stages.

	Total fiber (g/100g)	Total sugars (g/100g)
Orange		
Ripe	0.97±0.0^{c}	04.96±0.2^{e}
Very ripe	0.52±0.0^{d}	06.25±0.1^{c}
Sweet Banana		
Ripe	1.12±0.2^{b}	02.47±0.0^{g}
Very Ripe	1.03±0.3^{c}	04.73±0.1^{e}
Apple fruit		
Ripe	**1.33±0.1^{a}**	02.94±0.0^{g}
Very Ripe	1.00±0.1^{c}	**08.96±0.1^{a}**
Mango		
Ripe	1.01±0.1^{c}	03.01±0.1^{f}
Very Ripe	1.02±0.1^{c}	05.35±0.2^{d}
Papaya		
Ripe	**1.49±0.2^{a}**	02.21±0.0^{g}
Very Ripe	0.97±0.1^{c}	**09.02±0.3^{a}**

Concerning the free total sugar content of the fruits at the two maturity stages studied, the statistical analysis highlighted the existence of a significant difference ($p < 0.05$) between ripe and very ripe fruits with the very ripe fruits recording the highest content. Indeed, banana contains 2.47±0.0% of total sugars at the ripe stage compared to 4.73±0.1% at the very ripe stage; Similarly, the other fruits, i.e. apple, mango, orange and papaya, have total sugar contents ranging from 2.94±0.0%, 3.01±0.1%, 4.96±0.2% and 2.21±0.0% at the ripe stage, respectively, to 8.26±0.1%, 3.01±0.1%, 6.25±0.1% and 9.02±0.3% at the very ripe stage. The total sugar content was on average doubled when moving from ripe to very ripe for all fruits with a greater increase for apple fruit (tripled) and papaya (quadrupled).

Similarly, when the total free sugar content is compared indifferently at the ripe and very ripe stages, it can be seen that the highest contents are recorded at the very ripe stage, with papaya (09.02±0.3) and apple (08.26±0.1) exhibiting the highest sugar contents. On the other hand, it is at the ripe stage that the lowest total free sugar contents were recorded in sweet banana (02,47±0,0%), papaya (02,21±0,0%) and apple (02,94±0,0%).

On the other hand, in the case of crude fibre content, the opposite trend is observed when moving from the ripe to the very ripe stage of the fruit studied, with a significant drop during the transition from one stage to the other (table 3). Indeed, the banana contained 1.12±0.2% crude fibre at the ripe stage which dropped to 1.03±0.3% at the very ripe stage; Similarly, the other fruits, i.e. apple, mango, orange and papaya, had crude fibre contents ranging from 1.33±0.1%, 1.01±0.1%, 0.97±0.0% and 1.49±0.2% at the ripe stage, respectively, which decreased significantly to 1.00±0.1%, 1.02±0.1%, 0.52±0.0% and 0.97±0.1% at the very ripe stage.

Discussion

The objective of this study was to identify the main determinants of fruit consumption by diabetic patients at the Abidjan Antidiabetic Center (Côte d'Ivoire) and to characterize the nutritional potential of these fruits in terms of crude fiber and total free sugar content.

This study found that the majority of diabetic patients treated at CADA were female. This female predominance among diabetic patients could be explained by the fact that women are more sedentary in our society (Sangala, 2020). This is a real risk factor for obesity and type 2 diabetes. This sexual dysmorphia has also been observed in overseas departments and in sub-Saharan Africa where type 1 and type 2 diabetes are more common in the female population (Fagot-campagna et al., 2010). These results are in agreement with those of Meisinger *et al* (2006) who showed higher adiposity indices in women than in men, exposing them more to metabolic diseases such as diabetes, hypertension, etc. Indeed, the biochemical and physiological changes during pregnancy, materialized by weight gain and the adverse effects of estrogen on fat, predispose them first to gestational diabetes mellitus but also to the development of diabetes later (Grant, 2009). Moreover, the classification of these diabetic

patients according to their age group showed a predominance of people aged 50 to 65 years, i.e. 44.3%. These results are in agreement with the survey conducted by the Ivorian Federation of Diabetics (IFD) in 2011, which showed a peak in the prevalence of diabetes among diabetic patients between 40 and 59 years of age with a 3 to 4-fold increase in the risk of developing diabetes after 44 years of age. According to Lopez (2006), people aged 45 to 59 years were 8.5 times more likely to develop diabetes than those aged 15 to 29 years, and people over 60 years were 12.5 times more likely to develop the disease. This may be related to the progressive increase in insulin resistance with age, physical inactivity, and longevity of patients with type 2 diabetes due to improved care (Grant, 2009).

Regarding the management of diabetic patients, this study highlighted the fact that less than one third of diabetic patients (28.5%) consulted a dietician. Furthermore, the assessment of the knowledge of these patients on the nutritional benefits of fruit revealed to some extent a lack of knowledge in this area for less than a third of the respondents, i.e. 26.7% who had no knowledge of the benefits of fruit consumption. They did not know that fruit contains essential nutrients, micronutrients such as vitamins, minerals, fiber and compounds with antioxidant potential that play an important role in their health. For example, more than half, 51.5%, did not know that fruit contains sugar. This lack of knowledge may be due to the fact that very few of them (diabetic patients) have attended the nutrition trainings provided by the dieticians in the CADA.

However, 28.5% of diabetics in this study reported having nutritional knowledge about fruit. This underscores the importance of allowing people with diabetes to participate in regular nutrition education sessions and the need to tailor these trainings to the availability of patients so that many, if not all, have the opportunity to attend. In Quebec, the Canadian Task Force on Preventive Health Care (CTFPHC) has recommended and recognized as effective dietary counseling of more than six sessions of more than 30 minutes each (Chaumartin, 2008).

Therapeutic education is another educational approach recognized as effective. In France, an experimental study testing the feasibility and effectiveness of caregiver training and patient education programs adapted to community health professionals showed a positive influence on the quality of life of type 2 diabetic patients (Foucaud et al., 2010). This approach, beyond the transmission of information, takes into account the psychosocial and environmental aspects of patients. Regarding the frequency of fruit consumption by diabetic patients, the study found that the majority consumed very little fruit. Many consumed at least one fruit every 1-2 days, while some consumed at least one fruit every 3-4 days or more. These results were in agreement with those of Rejman et al. (2021) who showed among young Polish adults (18-35 years, equal proportions of both sexes) that almost half eat fruit at most once a day and only 7.5% eat it 4-5 times a day. However, some authors such as Ramon (2009) recommend eating fruit 5-6 times a day, which is far from being practiced by the diabetic patients surveyed. Similarly, other studies of increased fruit and vegetable consumption by individuals with type 2 diabetes ($\geq$ 6 servings/d) have shown increased levels of carotenoids (Enriquez-Valencia et al., 2020), and enzymes (Daniels et al., 2014) in these patients coupled with a significant decrease in glycosylated hemoglobin (Jenkins et al., 1981), which is beneficial for patients with diabetes. The low consumption of fruits by the respondents was reported to be due to lack of information about the health benefits of fruit consumption. Similarly, a study by Sadia (2022) in Bangladesh found that low fruit and vegetable consumption was due to non-economic factors, such as traditional eating habits, socio-demographic characteristics and attitudes towards food. In contrast, the economic components of low fruit and vegetable consumption tend to be related to lifestyle changes due to urbanization and globalization. An educational effort on the importance of fruit consumption could increase interest in fruit consumption among patients with diabetes (Weinstein et al., 2014; Dreher, 2018).

In addition, the consumption of fruits by the respondents was related to the seasons and the availability of fruits in the market. The fruits most consumed by CADA diabetic patients were orange (*Citrus sinensis*), papaya (*Carica papaya*), mango (*Mangifera indica*), sweet banana (*Musa paradisiaca*) and apple (*Malus domestica*). This choice of tropical fruits would be due to the fruit consumption habits of these patients. Indeed, according to a study conducted by Kim et al. (2014), fruit and vegetable consumption could be influenced by taste preferences, repeated exposure to fruits and vegetables, social experiences, and availability of these fruits.

Regarding the amount of fruit consumed by diabetic patients, the survey revealed that the majority of patients consumed 1 to 2 fruits per meal. These results are in agreement with the National Nutrition and Health Program (PNNS) which recommends since 2001 for all (children, adolescents and adults), to consume at least 5 fruits or vegetables per day. In addition, according to the World Health Organization (WHO, 2021), it is recommended to consume at least 400 g of fruit and vegetables per day, or 5 x 80 g portions, for adults and children. However, due to a number of factors, such as availability, affordability or lack of knowledge and awareness, the typical daily consumption of fruit among many people around the world is well below the recommended level (Dreher, 2018; Willett et al., 2019). Thus, most patients surveyed consumed fruit after meals, 44.6% as desserts and 29.7% outside of meals in terms of snacks. However, Steinert et al. (2016) recommend consuming soluble fiber-rich foods before meals rather than as snacks. This is because fiber-rich fruits improve satiety by increasing chewing effort and initiate cephalic responses (Farajian et al., 2010; Slavin, 2015), stimulating the production of gut hormones (Li et al., 2011) such as Glucagon-Like Peptide 1 (GLP-1) which slows gastric emptying and allows individuals to feel full longer (Wu et al., 2011). Shukla et al. (2018) also reported a significant increase in plasma GLP-1 in individuals who consumed protein and vegetables prior to a carbohydrate meal compared to those who consumed carbohydrates after a meal. In addition, the survey revealed that the majority of diabetic patients preferred to consume whole fruit rather than juice. These results corroborate those indicated by Canada's Food Guide (Health Canada, 2007), which recommends consuming whole fruit rather than juice. Indeed, consuming fruits and vegetables as part of a healthy diet low in sugar, salt, and fat is thought to help prevent weight gain and obesity, which is an independent risk factor for noncommunicable diseases (WHO, 2014).

Vegetables and fruit contain important nutrients such as vitamins, minerals and fibre (Health Canada, 2007; Fernandes et al., 2023). In particular, fruits contain vitamins A and C, potassium, magnesium and some B vitamins such as folate. They are also a good source of polyphenolic compounds (catechins, anthocyanins, isoflavones, resveratrol, quercetin, genistein, etc.) which have antiproliferative, antidiabetic, anticancer, antimicrobial, anti-inflammatory, antiviral, antioxidant properties and significant amounts of these bioactive substances (Dhalaria et al., 2020). These nutrients have a number of health benefits for people in general and diabetic patients in particular. A diet rich in vegetables and fruits can help reduce the risk of cardiovascular disease, stroke, and certain types of cancer (Crowe et al., 2011; Che Mohd Zin et al., 2022).

With regard to fruit ripeness at consumption, the survey indicated that the majority of diabetic patients at the CADA paid attention to the ripeness level of fruit before consuming it and consumed it ripe or very ripe. According to Potter and Hotchkiss, 1998, the term taste (or food) ripeness of fruit is used to describe the optimal state of color, flavor, and texture of a fruit. Indeed, the most flavorful fruits are those that are allowed to ripen naturally on the tree. Thus, the longer the fruit remains attached to the tree, the higher its sugar content at harvest (Pimentel and Walder 2004). However, it is not always possible to obtain ripe fruit on the tree. In order to have time to supply more distant markets, it is recommended to harvest the fruit when it is ripe (or unripe) (Pimentel and Walder 2004) and transport it to the markets where it will be sold.

The crude fiber content of the analyzed fruits is variable according to the type of fruit and the maturity level. It increases from the ripe to the very ripe stage with values ranging from 0.52 to 1.49 g/100g dry matter. Regarding the type of fruit, ripe papaya contained more dietary fiber, followed by ripe apple and other ripe fruits, while low levels were found in very ripe and ripe orange and very ripe papaya. These results were similar to those of the study by Kouakoua *et al* (2021) which found lower fiber values for banana (0.29%), papaya (0.67%), pineapple (0.53%) and saba (0.18%). Indeed, the presence of dietary fiber may contribute to a reduction in the glycemic response resulting from the consumption of carbohydrate-rich foods. Targeting and controlling postprandial glycemic values is essential for the prevention and management of diabetes (Giuntini et al., 2022). In the intervention study involving fiber supplementation in people with type 2 diabetes, this diet was shown to reduce fasting blood glucose and HbA1c (Kaczmarczyk et al., 2012). Most nutritionists recommend an intake of 18-38 g of fiber/day for adults, or approximately 8-20 g per 1000 kcal (Health Canada, 2022; Cheong, 2022). The WHO/FAO and EFSA recommend an average daily intake of 25 g of fiber per adult (Crawford et al., 2010; Nishida et al., 2004). Therefore, it is recommended to consume whole fruits rather than fruit juices, as fruit juice consumption has not shown a positive effect on blood glucose and insulin

levels (Wang, 2014). Other authors recommend fiber intakes of 15-28 Kcal per 100 g (Ramon, 2009).

Regarding total sugars, the results show that the amount of sugar increases as the fruit ripens and these fruits contain low amounts of sugars at the ripe and very ripe stage, with the exception of the very ripe papaya. This is because the consumption of sugars, unlike fiber, causes an increase in blood sugar levels. However, the sugars naturally present in fruit are nutritious and part of a healthy diet. In addition, fruits are primarily composed of fructose (Basciano et al., 2005) which is absorbed in the small intestine more slowly than glucose and does not overload the pancreatic system. However, the long-term effects of fructose can be deleterious. For example, diets high in fructose are suspected of inducing hypertension, insulin resistance, impaired glucose tolerance, obesity and dyslipidaemia (Tappy et al., 2010). Therefore, consumption of ripe and very ripe fruits with total soluble sugar levels lower than the levels (11-13 g/100g) obtained by Tandu et al. (2001) for the analyzed fruits could help regulate blood glucose levels throughout the day without glycemic peaks. The difference observed between the results of the present study for some fruits with respect to total fiber and sugar content could be explained by the difference in environmental conditions and the intrinsic potential of each fruit.

Conclusion

This study revealed that the majority of patients followed at the Abidjan Diabetes Center were women, mostly between the ages of 50 and 65. Although these patients generally did not consume fruits regularly because of their sweet taste, oranges, apples, sweet bananas, papayas and mangoes were the fruits most consumed by the segment of patients who did consume them. They consumed 1 or 2 fruits at each intake, preferred them ripe or very ripe, whole and preferably after meals. In addition, these different fruits were good sources of free sugars and dietary fiber, whose content increased with the degree of ripeness of the fruit, whereas fiber decreased. In view of the above, fruit consumption by diabetic patients should be the subject of nutritional education to enable them to make better choices for their health.

Conflict of interest statement

Authors declare that they have no conflict of interest.

References

Agbo N.G., Uebersax M., Hosfield G. (1986). An efficient extraction technique of sugars from dry edible beans (*Phaseolus vulgaris*) and estimation in HPLC, Université Nationale de Côte d'Ivoire. Annals serie C (sciences) Tome XXI. 169-184.

American Diabetes Association (ADA), (2022). Professional Practice Committee. Standards of medical care in diabetes -. Diabetes Care 2021 ; 45 : Supplement 1.

AOAC. (1990). Official methods of analysis, 14th edition, Association of Official Analytical Chemists, Washington DC. Arlington, Virginia, USA.

Aune D., Giovannucci E., Boffetta P., Fadnes L.T., Keum N.N., Norat T., Greenwood D.C., Riboli E., Vatten L.J., Tonstad S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-A systematic review and dose-response meta-analysis of prospective studies. Int. J. Epidemiol. 46, 1029–1056. [CrossRef]

Basciano H., Federico L., Adeli K., (2005). Fructose, insulin resistance, and metabolic dyslipidemia. Nutrition & Metabolism, 21, 5. doi:10.1186/1743-7075-2-5.

Chaumartin D. (2008). Survey of fifteen type 2 diabetic patients: status of their knowledge and adherence to hygienic-dietary measures [Thesis]. Saint-Étienne : Université de Saint Étienne, Faculté de médecine Jacques Lisfranc; 2008. 37 p.

Che Mohd Zin C.A.J., Wan Mohd Izani W.M., Nurzalina A.K.K., Wan Rosli W.I. (2022). Effects of Fruit and Vegetable Polyphenols on the Glycemic Control and Metabolic Parameters in Type 2 Diabetes Mellitus: A Review. Prev. Nutr. Food Sci. 27(3):257-264.

Cheong, T. (2022). Why Is Dietary Fibre So Important? Singapore Health Promotion Board. Available online: http://www.healthxchange. com.sg/ healthyliving/ DietandNutrition/ Pages/ Why-Is-Dietary-Fibre-So-Important.aspx (accessed on 21 February 2022).

Crawford M., Bell G., Bueno A., Cunnane S., Clough P., Emmett P., Galli C., Golding J., Harbige L., Hibbeln J.R. (2010). Outcome of the Public Consultation on the Draft Opinion of the Scientific Panel on Dietetic Products, Nutrition, and Allergies (NDA) on Dietary Reference Values for Carbohydrates and Dietary Fibre. EFSA J. 8, 1507.

Crowe FL., Roddam A.W., Key T.J., Appleby P.N., Overvad K., Jakobsen M.U. (2011). « Fruit and vegetable intake and mortality from ischaemic heart disease: results from the European Prospective Investigation into Cancer and Nutrition (EPIC)-Heart study », European Heart Journal. 32:1235-43.

Daniels J.A, Mulligan C., McCance D., Woodside J.V., Patterson C., Young I.S. (2014). A randomised controlled trial of increasing fruit and vegetable intake and how this influences the carotenoid concentration and activities of PON-1 and LCAT in HDL from subjects with type2 diabetes.D:\Users\Dasein\Downloads\AB STRAT FRUIT 1.htm Cardiovasc Diabetol. Jan doi:10.1186/1475- 284

DeFronzo R.A., Ferrannini E., Alberti K.G.M.M., Zimmet P. (2015). International Textbook of Diabetes Mellitus. 4th Ed. Chichester : Wiley-Blackwell. 2V.

Dhalaria R., Verma R., Kumar D., Puri S., Tapwal A., Kumar V., Nepovimova E., Kuca K. (2020). Bioactive Compounds of Edible Fruits with Their Anti-Aging Properties: A Comprehensive Review to Prolong Human Life. Antioxidants, 9, 1123. [CrossRef]

Dreher M.L. (2018). Whole fruits and fruit fiber emerging health effects. Nutrients 10, 1833. [CrossRef]

Dubois M., Gilles K.A., Hamilton P.A., Ruberg A. et Smith F. (1956). Calorimetric method for determination of sugar and relative substances analytical chemistry 28.3: 350-356pp.

Enriquez-Valencia S.A., Julieta Salazar-Lopez N.J., Robles Sanchez M., Gonzalez-Aguilar G.A., Fernando Ayala-Zavala J., Lopez-Martinez L.X. (2020). Propriétés bioactives des fruits tropicaux exotiques et leurs bienfaits pour la santé. Archivos Latinoamericanos de Nutricion, 70:205-214.

Fagot-campagna I., Romon S., Fosse., Roudier C. (2010). Prévalence et incidence du diabète, et mortalité liée au diabète en France. Synthèse épidémiologique. Saint-Maurice : Institut de veille sanitaire.

Farajian P., Katsagani M., Zampelas A. (2010). Short-term effects of a snack including dried prunes on energy intake and satiety in normal-weight individuals. Eat. Behav. 11, 201–203.

Fernandes A., Mateus N., de Freitas V. (2023). Polyphenol-Dietary Fiber Conjugates from Fruits and Vegetables: Nature and Biological Fate in a Food and Nutrition Perspective. Foods, 12, 1052. https://doi.org/10.3390/ foods12051052.

Foucaud J., Bury J.A., Balcou-Debussche M., Eymard C. (2010). Éducation thérapeutique du patient. Modèles, pratiques et évaluation. Saint Denis: Inpes, coll. Santé en action : 412 p.

Frier B.M., Fisher B.M. (2004). Diabète sucré. Dans : Davidson. Médecine Interne. Principes et pratique. Paris: Maloine; p.641-682.

Gao F., Mei X, Li Y., Guo J., Shen Y. (2021). Update on the Roles of Polyamines in Fleshy Fruit Ripening, Senescence, and Quality. Front. Plant Sci. 12:610313. doi: 10.3389/fpls.2021.610313.

Giuntini E.B., Sardá F.A.H., De Menezes E.W. (2022). The Effects of Soluble Dietary Fibers on Glycemic Response: An Overview and Futures Perspectives. Foods, 11, 3934. https://doi.org/10.3390/ foods11233934

Grant J., Hicks N., Taylor A., Chittleborough C., Phillips P. (2009). North West Adelaide Health Study Team. Gender-specific epidemiology of diabetes: a representative cross sectional study. International Journal for Equity in Health, 8:9. Available at: http://www. equi tyhealthj.com/content/8/1/6.

Gurukar M.S., Mahadevamma S., Chilkunda N.D. (2013). Renoprotective effect of Coccinia indica fruits and leaves in experimentally induced diabetic rats. Sep;16(9):839-46. doi: 10.1089/jmf.

He F.J., Nowson C.A., Lucas M., MacGregor G.A. (2007). Increased consumption of fruit and vegetables is related to a reduced risk of coronary heart disease: Meta-analysis of cohort studies. J. Hum. Hypertens. 21, 717–728.

Health Canada (2022). Food Directorate, Bureau of Nutritional Sciences, Health Products and Food Branch. Policy for the labelling and advertising of foods containing dietary fibre. Available online: http://www.hc-sc.gc.ca (accessed February 19, 2022).

IDF. (2019). Atlas du Diabète de la FID, 9e éd. FID. Bruxelles, 167 p.

IDF. (2021). Diabetes Atlas. 10th edition. 2021. Disponible sur : diabetesatlas.org/atlas/tenth-edition/.

IDF. International Diabetes Federation (2011). Diabetes Atlas 5 th ed. . Brussels.

Jenkins D.J.S., Wolever T.M.S., Taylor R.H.S., Barker H.S., Fielden H.S., Baldwin J.M.S., Bowling A.C., Newman H.C., Jenkins A.L., Goff D.V. (1981). Glycemic index of foods: a physiological basis heart carbohydrate exchange. American Journal of

Clinical Nutrition, 34: 362-366.

Kaczmarczyk M.M., Miller M.J., Freund G.G. (2012). The health benefits of dietary fiber: beyond the usual suspects of type 2 diabetes mellitus, cardiovascular disease and colon cancer. 61(8):1058-66. doi: 10.1016/j.metabol. 01.017. Epub.

Kim S.A., Moore L.V., Galuska D., Wright A.P., Harris D., Grummer-strawn L.M. (2014). Fruit and Vegetable Intake Among Children -United States, August, / 63(31);671-676.

Kouakoua Y.A., Coulibaly A., Kouadio O.K., Gnagne E.H., Amani N.G. (2021). Comparative study of the nutritional potential of a wild fruit (Saba senegalensis) from Côte d'Ivoire with pineapple, papaya and banana. Int. J. Biol. Chem. Sci. 15(5): 1791-1799.

Li J., Zhang N., Hu L., Li Z., Li R., Li C., Wang, S. (2011). Improvement in chewing activity reduces energy intake in one meal and modulates plasma gut hormone concentrations in obese and lean young Chinese men–. Am. J. Clin. Nutr. 94, 709–716.

Lopez D., Colin D. M. (2006). Global Burden of Disease and Risk Factors. Oxford University Press and The World Bank.

Mamluk L., O'Doherty M.G., Orfanos P., Saitakis G., Woodside J.V., Liao L.M., Sinha R. Boffetta P., Trichopoulou A., Kee F. (2017). Fruit and vegetable intake and risk of incident of type 2 diabetes: Results from the consortium on health and ageing network of cohorts in Europe and the United States (CHANCES). Eur. J. Clin. Nutr. 71, 83–91. [CrossRef]

Meisinger C., Doring A., Thorand B., Heier M., Lowel H. (2006). Body fat distribution and risk of type 2 diabetes in the general population: are there differences between men and women? The MONICA/KORA Augsburg cohort study. American Journal of Clinical Nutrition, 84:483 489.

Nishida C., Uauy R., Kumanyika S., Shetty P. (2004). The Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases: Process, Product and Policy Implications. Public Health Nutr. 7, 245–250. [CrossRef] [PubMed]

Osei-Yeboah J., Owiredu W., Norgbe G., Obirikorang C., Lokpo S., Ashigbi E. (2019). Physical Activity Pattern and Its Association with Glycaemic and Blood Pressure Control among People Living with Diabetes (PLWD) In The Ho Municipality, Ghana. Ethiop J Health Sci. 29(1):819-30.

Pimentel R.M.A., Walder J.M.M. (2004). Gamma radiation in papaya harvested at three stage of maturation. Scientia Agricola. 6(2) :146-150.

Potter N.N., Hotchkiss J.H. (1998). Food Science. Aspen Publishers Inc. Maryland.

Ramon C. (2009). Diabète, Traitement Scientifique et naturel, éd. Vidasana S.L. p142.

Rejman K., Górska-Warsewicz H., Kaczorowska J., Laskowski W. (2021). Nutritional Significance of Fruit and Fruit Products in the Average Polish Diet. Nutrients 13, 2079. https:// d13062079.

Sadia M. (2022). Patterns and Determinants of Consumers' Preferences and Demand for Fruits and Vegetables in Bangladesh. A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba In partial fulfillment of the requirements for the degree of Master of Natural Resources Management (M.N.R.M).

Sangala M. M. (2020). Observance thérapeutique chez les patients diabétiques au centre de sante de référence de la commune III du district sanitaire de Bamako. Thèse Med Bamako, p:51.

Shukla A.P., Mauer E., Igel L.I., Truong W., Casper A., Kumar R.B., Saunders K.H., Aronne L.J. (2018). Effect of food order on ghrelin suppression. Diabetes Care, 41, e76–e77.

Slavin J.L. (2015). Dietary fiber and body weight. Nutrition. 21, 411−418.

Steinert R., Raederstorff D., Wolever T. (2016). Effect of consuming oat bran mixed in water after a meal on glycemic responses in healthy humans-a pilot study. Nutrients, 8, 524.

Strand M. (2004). Ce que votre médecin ignore de la médecine nutritionnelle pourra vous être fatale, édition du trésor caché (Québec), Canada. p273.

Tandu U. (2001). Nutrition de la théorie à la pratique, presse de l'Université de Kinshasa p276.

Tappy L., Lê Ka, Tran C., Paquot N. (2010). Fructose and metabolic diseases: new findings, new questions. Nutrition 26: 1044–9.

Vincente A.R., Manganaris G.A., Ortiz C.M., Sozzi G.O., Crisosto C.H. (2014). Nutritional Quality of Fruits and Vegetables. In Postharvest Handling: A Systems Approach; Elsevier Inc.: Amsterdam, The Netherlands, pp. 69–122. ISBN 9780124081376.

Wang B., Liu K., Mi M., Wang J. (2014). Effect of fruit juice on glucose control and insulin sensitivity in adults: a meta-analysis of 12 randomized controlled trials. Apr 17;9(4):e95323.

Weinstein E., Galindo R.J., Fried M., Rucker L., Davis N.J.D. (2014). Impact of a focused nutrition educational intervention coupled with improved

access to fresh produce on purchasing behavior and consumption of fruits and vegetables in overweight patients with diabetes mellitus. Jan Feb; 40 (1): 100-6. doi: 10.1177/0145721713508823.

WHO (2021). Promoting Fruit and Vegetable Consumption around the World. Available online: https://www.who.int/ dietphysicalactivity/fruit/en/

Willett W., Rockström J., Loken B., Springmann M., Lang T., Vermeulen S., Garnett T., Tilman D., DeClerck F., Wood A. (2019). Food in the Anthropocene: The healthy diets from sustainable food systems. Summ. Rep. EAT-Lancet Comm., 393, 447–492.

World Health Organization (WHO) (2014). Increasing fruit and vegetable consumption to reduce the risk of non-communicable diseases: Available at: https://www.who.int/elena/titles/bbc/fruit_vegetables_ncds /en/

Wu T., Zhao B.R., Bound M.J., Checklin H.L., Bellon M., Little T.J., Young R.L., Jones K.L., Horowitz M., Rayner C.K. (2011). Effects of different sweet preloads on incretin hormone secretion, gastric emptying, and postprandial glycemia in healthy humans. Am. J. Clin. Nutr. 95, 78–83.

How to cite this article:
Yapo, B.F., Doue, G.G., Gbakayoro, J-B., Dakia, P.A., Brou, K., 2023. Main determinants of the fruits consumed by diabetic patients managed at the Antidiabetic Center of Abidjan (Côte d'Ivoire). Int. J. Curr. Res. Biosci. Plant Biol., 10(2): 11-22. **doi:** https://doi.org/10.20546/ijcrbp.2023.1002.002