Physicochemical and Nutritional Properties of Varieties of Carrot (*Daucus carota*) grown in Region of Korhogo, North of Côte d'Ivoire

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Abstract—Very popular for its therapeutic and nutritional virtues, culture of carrot (Daucus carota) has developed in temperate zones of Asia and Europe but also in some tropical regions of Africa including Côte d'Ivoire. Agronomic factors, commercial and food requirements require selection of varieties with good nutritional values. In this study, physicochemical properties and nutritional values of four carrot varieties namely Amazonia, Bahia, Madona and Pamela+ were compared after cultivation and harvest in region of Korhogo. Results showed that, Amazonia, the control carrot variety stands out for its acidity and minerals levels. Bahia is the richest variety with high levels of carbohydrate and protein. Madona is the most basic, wettest and fatest carrot. For a long storage, Pamela is most interesting variety. To our knowledge, it is the first time that physicochemical and nutritional parameters of carrot varieties in region of Korhogo have been studied. Future research on these carrot varieties will be studied of their post-harvest conservation, their sensory analysis and their transformation.

Keywords—Carrot varieties, Daucus carota, Korhogo, nutritional values, physicochemical properties.

I.   INTRODUCTION

Carrot (*Daucus carota*) is a bi-annual herbaceous plant of the Apiaceae family grown for its taproot which is edible fresh or cooked. Developed as a spare and unbranched organ (in loose soil, without obstacle), its root is fleshy, brittle, pigmented (but rarely white) with pleasant taste. Carrot is well known to be rich in carotene, vitamins, proteins, sugar and minerals (Le Clerc, 2001; Reduron, 2007). Carrot is the most important economically species

in the Apiaceae family (Rubatzky *et al.*, 1999). It is one of most popular root vegetables grown in the world and most important source of food carotenoids in Western countries, including United States of America (Block, 1994; Torronen *et al*., 1996). This root vegetable is much consumed in the world because of its nutritional value, its simple and various modes of consumption (Chaux & Foury, 1994). Carrot is one of the ten most important worldwide vegetable crops for area of production and market value (Simon *et al.*, 2008). In addition to its consumption, carrot is also used as a dye plant to color butter or certain cheeses (Reduron, 2007). There are various colors of carrot (yellow, pink, purple, white, etc.) related to difference in carotenoid content (Clotault *et al.*, 2008; Clotault, 2009). However, orange carrot gradually supplanted all other colors because of its more desirable hue, especially after cooking (Reduron, 2007). This type of carrot is generally the most rich in total carotenoids. The two major carotenoids in orange carrot are β-carotene and α-carotene. It also contains a low proportion of lutein (Nicolle *et al.*, 2004; Clotault, 2009). Many orange cultivars have appeared over time with in particular a diversification of root forms. Thus, the vegetable carrot has diversified into local varieties to respond to crop patterns and various situations (Pitrat & Foury, 2003; Doré & Varoquaux, 2006). The food interest of the root of carrot concerns its taste, its color, but also its nutritional characteristics (Aubert & Bonnet, 1977; Tirilly & Bourgeois, 1999). Interest is more and more also focused on nutraceutical compounds of this root because of their importance for good health. Indeed carrot is an interesting food for its content of antioxidant compounds, mainly anthocyanins or chlorogenic acid and carotenoids (Sun *et*

al., 2009). β-carotene or provitamin A is the carotenoid which is transformed by human metabolism into vitamin A (Dreosti, 1993; Lecomte, 2013). The consumption of carrot contributes to a healthy and balanced diet (Shankara *et al.,* 2005). Very popular for its therapeutic and nutritional virtues, culture of carrot has developed in temperate zones of Asia and Europe but also in some tropical regions of Africa including Côte d'Ivoire. In addition to agronomic factors (precocity, high yields, pest resistance), commercial and food requirements require the selection of varieties with good nutritional values.

Objective of this study is to compare physicochemical and nutritional properties of four hybrid varieties of carrots, namely Amazonia, Bahia, Pamela+ and Madona, grown in northern Côte d'Ivoire.

II. MATERIALS AND METHODS

2.1. Zone of study

Study was conducted in commune of Korhogo, located in northern Côte d'Ivoire. Geographic coordinates of this area are 9° 26' North Longitude and 5° 38' West Latitude. Climate is Sudanese, very hot, very dry and characterized by an alternation of two main seasons: the dry season and rainy season. Dry season runs from November to April and rainy season from May to October. Maximum rainfall is achieved in August and September and varies between 255 and 267 mm, with an annual average of about 1200 mm. The dry season of this climate is marked by harmattan which is a hot and dry wind from Northeast whose peak is between December and January. Average temperatures vary between from 24 to 33 °C with a monthly average humidity of 20%. Soil profile of region is characterized by the very large predominance of ferralitic soils. In general, these soils have very variable saturation levels between 20 and 50%. Relief is generally flat and dotted with inselbergs. Average annual duration of sunstroke in this geographic zone is 2500 hours. Monthly average is about 205 hours in the dry season compared to nearly 140 hours during months of July and August who are the most watered (Koffie & Yéo, 2016).

2.2. Plant material

Plant material is composed of four hybrid varieties of carrot (*Daucus carota* sub. sp. *Sativus*), belonging to the Kuroda type. These varieties are known by their vernacular names. Variety namely Amazonia is the most cultivated in the region of Korhogo. It has been used as control in this study because its agronomic characteristics are well known. After 90 to 95 days of cultivation, the pivoting roots of Amazonia can reach 16 to 18 cm long (Technisem, 2017)**.**

2.3. Conduct of experimentation

Test was conducted using a completely randomized block device of Fisher with four (4) treatments and four (4) repetitions. Study consisted of sixteen (16) elementary plots. Each sub-plot consisted of seventy-two (72) plants, transplanted on six (6) lines according to spacings of 25 cm x 8 cm (25 cm between two lines and 8 cm between two plants in the same line). Each elementary plots had an area of 2 m^2 each and the blocks, were respectively separated by a distance of 50 cm and 80 cm. Whole plot consisted of one thousand one hundred and fifty-two (1152) plants on a total area of around 60 cm^2. Test was conducted in dry season (off-season period). Two (2) kilograms (kg) of fully decomposed chicken manure were added to each basal plot as background fertilizer two weeks prior to carrot seeding. After sowing, mulching of plots was done to maintain sufficient soil moisture after watering operations. Thinning was done at the stage of appearance from 3 to 5 leaves (22 to 35 days after emergence of plants). Purpose of thinning was to maintain spacing of 8 cm between plants on same line. Weeding has been regularly carried out to eliminate weeds and ensure good aeration of soil. A first mineral fertilization was carried out on 46th day after sowing with mineral fertilizer NPK (formula: 12-11-18+2.7MgO+8S+B+Fe+Zn+Mn) at rate of 50 g per elementary plot. A second mineral fertilizer (formula: 15.4N+25.6CaO+0.3B) was applied 3 weeks after first amendment of the soil, at a rate of 30 g per elementary plot. Preventive treatments against insects were applied on the plots once a week from 8 leaves (66 days after emergence of plants) with the product "Cypercal" provided by Callivoire (Côte d'Ivoire) at rate of 1 l/ha. This dose is equivalent to a mixture of 6.6 ml of the product and 2.5 l of water per elementary parcel. The carrot roots were harvested from 90th day after emergence of plants (3 months and week after sowing).

2.4. Analytical procedures

Root samples of four (4) varieties of carrots from experimental test were cleaned in the laboratory to remove foreign elements. These roots were crushed using an electric grinder (Clatronic KM 3648, France) with perforated disk of 10 μm of diameter. The grind of each variety of carrot was put carefully in closed bottle and stored in refrigerator at 4 °C before their use for biochemical and nutritional analyzes.

Physicochemical parameters of samples of each variety of carrot were determined according to the official methods of analysis of Association of Official Analytical Chemists (AOAC, 1990). Moisture content of samples was determined by desiccation using the method of De Knegt & Brink (1998). A clean platinum dish was dried in an oven (Memmert UN 110, Allemagne) and cooled in a

desiccator and weighed. From each sample, 10 g was weighed and spread on the dish. Then the dish containing the sample was weighed. It was then transferred into the air oven at 105 °C to dry until a constant weight was obtained and the loss in mass was determined. In order to obtain the pH of the samples, 10 g of each sample was weighed and suspended in 10 ml of distilled water. The pH was determined with a digital pH-meter (Hanna EUTECH INSTRUMENTS PH 700, Espagne). Titratable acidity of samples was determined by titration with 0.1 N of sodium hydroxide solution, using phenolphthalein as indicator. The results are calculated in citric acid equivalent and expressed in g/l of acid (Abbas & Khoudi, 2016).

For nutritional parameters, carbohydrate was determined according to phenol sulfuric acid method (Dubois *et al.,* 1956). A standard curve was obtained using the following concentration of sucrose in (mg/ml) 2.5 2.0, 1.25, 1.0, 0.5 g of each sample with 9 ml of distilled water was measured into test-tube. 2 ml of phenol solution (1%) and 1 ml of concentrated H_2SO_4 solution were added. This was shaken for 15 min and boiled for 30 min. It was then allowed to cool. The absorbance was then read off a spectrophotometer (UV-Visible, type 7315) at 700 nm. The sugar concentration was then obtained by extrapolation from the standard curve. Protein was analyzed by the Microkjedhal nitrogen method, using a conversion factor of 6.25 according method described by Hamon *et al.* (1990). Lipid content was obtained by Soxhlet extraction as described by Lecoq (1965). Ash was determined according to the standard methods described by the Association of Official Analytical Chemists (AOAC, 1990). Five (5) g of sample of carrot crushed was ashed in a muffle furnace Pyrolabo, France) at 550 °C. Percentage of residues obtained after incineration corresponds to ash content.

2.5. Statistical analyzes

Data collected in triplicates from these studies were analyzed using Statistical Analysis Software XL-STAT version 7.5.3. Data were expressed as means, giving relative standard deviations. The Student Newman Keuls test (SNK) with 5% of signification was used to discriminate the means. Correlations and a principal component analysis (PCA) were realized in order to detect differences that discriminate the carrot varieties.

III. RESULTS AND DISCUSSION

Results obtained for physicochemical and nutritional parameters of four carrot varieties are presented in Table 1. Variance analysis for each parameter studied revealed significant differences between four carrot varieties according to SNK test at 5 %.

3.1. Physicochemical properties

Moisture content of carrot varieties varies from 86.3 to 87.2% (SNK, 5%). Analysis of these data shows that carrot Palema+ is a variety which has the highest moisture content with 87.2% compared to other varieties (86.96 – 86.21%). These values revealed that carrot is a wet root. Moreover, these values corroborate those of other authors which showed that moisture content of carrots varies from 86 to 89% (Gopalan *et al.*, 1991; Arscot & Tanumihardio, 2010). However, studies of Cohen *et al.* (2009) showed that moisture content of carrot is 89%, while those of Holland *et al.* (1991) reported a value of 88.80%.

Varieties of carrots analyzed are pH values ranging from 6.51 to 6.60. There are slightly acidic according to pH scale of the products (Anonyme, 2009). Analysis of variance (SNK, 5%) revealed significant difference between these pH. Control variety Amazonia and variety Pamela+ have approximate pH values of 6.51 and 6.47 respectively. These values are significantly lower than those of Bahia and Madona varieties who are also neighbors with respectively pH of 6.63 and 6.60. These results are almost similar to those of Abbas and Khoudi (2016) who reported a pH value of 6.53 for carrot puree. The studies of Argha and Gavin (2016) revealed however average value of pH of the carrot between 4.9 and 5.2. Indeed, according to Anonyme (2009), pH of some products may vary with varietal characteristics, growing conditions and others factors.

For titratable acidity, Analysis of variance showed significant difference between varieties of carrot studied. The highest acidity has been observed in control variety Amazonia with 0.192 g/l while Bahia is the least acidic variety with 0.156 g/l. The other two varieties, Madona and Pamela+ presented intermediary values with respectively acidities of 0.169 and 0.171 g/l. However, studies of Abbas and Khoudi (2016) on carrot puree reported titratable acidity of 0.2 g/l. Result obtained by these authors show that varieties of carrot of our study are slightly acidic and must be pleasant to eat.

3.2. Nutritional properties

Carbohydrate contents between 5.62 and 6.71% are observed with carrot varieties studied. Bahia is carrot variety with highest carbohydrate content (6.71%) while control variety gave the lowest (5.62%). Madona and Pamela+ varieties showed respective intermediate rates of 6.45 and 6.29%. Our results are quite similar to those of Cohen *et al.* (2009) who reported a value of 6.7%. However, these rates obtained in our study are lower than those of carrot varieties studied by Arscot and Tanumihardio (2010) with 7%.

For protein, contents of carrot varieties are ranged between 2.71 and 3.66%. Analysis of variance (SNK, 5%)

revealed significant difference between these values. Variety Amazonia, as control showed the lowest protein level with 2.71%, followed by Madona which contains 2.89%. Varieties Pamela+ and Bahia revealed high proportions of protein with respectively 3.15 and 3.66%. These protein levels are well above those obtained through work on other carrot varieties. These protein levels are well above those obtained by Gopalan *et al*. (1991), Holland *et al*. (1991) and Cohen *et al*. (2009) on others varieties of carrots. The work of all these authors, indicated protein proportions in carrot ranging from 0.7% to 1.1%.

Lipid contents of varieties of carrot analyzed are between 0.79 % and 0.84 %. These values are significantly different according to SNK test at 5%. Lowest content of lipid is observed with Pamela+ carrot variety (0.79 %) while variety Bahia showed highest level of 0.84 %. Madona and Amazonia varieties presented intermediary and approximate contents of lipid with respectively 0.83 % and 0.82 %. Lipid contents of carrot varieties studied are higher than those of Gopalan et *al*. (1991), Holland et *al*. (1991) and Cohen *et al*. (2009) who respectively obtained lipid levels of 0.2%, 0.5% and 0.3% with other carrots. These results show that carrots of our study are rich in lipids.

Ash contents of carrots studied varies between 0.89% and 1.3%. These results showed a significant difference between varieties analyzed according to SNK test at 5%. Amazonia variety gave highest ash content with value of 1.3% followed by Madona who showed 1.24% of ash. The two others carrot (Bahia and Pamela+) presented lowest ash rates with same value (0.89%). On average, ash content of carrot studied is similar to that of Gopalan et *al*. (1991) with a rate of 1.1%.

3.3. Correlations between parameters

According to Pearson test, analysis of results revealed significant correlations between some parameters (Table 2). Most significant positive correlations are between moisture and lipids (R^2 = 0.92) and lipids and pH (R^2 = 0.93). Most negative correlations are between titratable acidity and carbohydrates (R^2 = -0.989).

3.4. Discrimination of carrot varieties

Two axes F1 and F2, allowed to express 95.71% of variability of observations (Table 3 and Fig. 1). Axis 1 (F1) contributed to 58.67% of observed variance and axis 2 (F2) to 37.03%. The parameters of carrot varieties studied which have best express on F1 axis are titratable acidity level (which is positively correlated with it), pH, carbohydrate and protein contents (negaticely correlated to this axis). For second axis (F2), lipid content, ash and moisture levels are variables positively correlated. The two

main axes F1 and F2 described four quarters of plans. Top right quarter above F1 axis and right of F2 axis, containing Amazonia variety. Upper left quarter of plan, above F1 axis and to left of F2 axis with Madona variety. Right lower quadrant, below F1 axis and to right of F2 axis with Pamela+ variety. Lower left quarter of plan which is located below F1 axis and to left of F2 axis including Bahia variety.

Distribution of variables in overall plan constituted by axes F1 and F2 was following. Ash level and titratable acidity are the two variables which appear in top right quarter of plan. pH, moisture and lipid contents are located in upper left quarter of plan. Carbohydrate and protein levels are shown in lower left quarter plan. No variable do not appears in lower right quarter of plan.

So Bahia variety is characterized by carbohydrate and proteins contents while Amazonia, a control variety is marked by ash and titratable acidity levels. pH, lipid and moisture levels were most important determinants of Madona variety. No parameters are characteristic of Pamela+ variety.

IV.   CONCLUSION

This study showed a significant variation in physicochemical and nutritional characteristics of the four carrot varieties grown in region of Korhogo. Investigations closed that, Amazonia, the control carrot variety stands out for its acidity and minerals levels. Nutritionally, Bahia is the richest variety with high levels of carbohydrate and protein. Madona is the most basic, wettest and fatest carrot. For a long storage, Pamela is most interesting variety. To our knowledge, it is the first time that physicochemical and nutritional parameters of carrot varieties in region of Korhogo have been studied. Future research on these carrot varieties will be study of their post-harvest conservation, their sensory analysis and their transformation. These studies will provide scientific data but also advice carrot varieties meeting requirements of growers and consumers in this region.

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TABLES

Table 1: Physicochemical and nutritional parameters of varieties of carrots

		Moisture (%)	pH	Acidity (g/l)	Carbohydrate (%)	Protein (%)	Lipid (%)	Ash (%)
Varieties	**Bahia**	86.437[a]	6.631[a]	0.156[b]	6.712[a]	3.656[a]	0.841[a]	0.890[c]
	Madona	86.210[a]	6.603[a]	0.169[b]	6.459[a]	2.886[c]	0.831[ab]	1.244[b]
	Pamela+	87.200[b]	6.472[b]	0.171[b]	6.293[a]	3.146[b]	0.786[b]	0.888[c]
	Amazonia*	86.692[a]	6.514[b]	0.192[a]	5.623[b]	2.715[d]	0.820[ab]	1.300[a]

*Control

Table.2: Correlation between parameters (Pearson (n)) :

Variables	Moisture	pH	Acidity	Carbohydrate	Protein	Lipid	Ash
Moisture	**1**	0.8915	-0.2649	0.3237	0.0287	0.9209	0.4521
pH	0.8915	**1**	-0.6307	0.6464	0.4785	0.9328	0.0087
Acidity	-0.2649	-0.6307	**1**	**-0.9893**	-0.8742	-0.3340	0.7189
Carbohydrate	0.3237	0.6464	**-0.9893**	**1**	0.7938	0.3358	-0.6426
Protein	0.0287	0.4785	-0.8742	0.7938	**1**	0.2760	-0.8552
Lipid	0.9209	0.9328	-0.3340	0.3358	0.2760	**1**	0.2602
Ash	0.4521	0.0087	0.7189	-0.6426	-0.8552	0.2602	**1**

Values in bold are most significant correlations.

Table 3: Values of variables along the axes

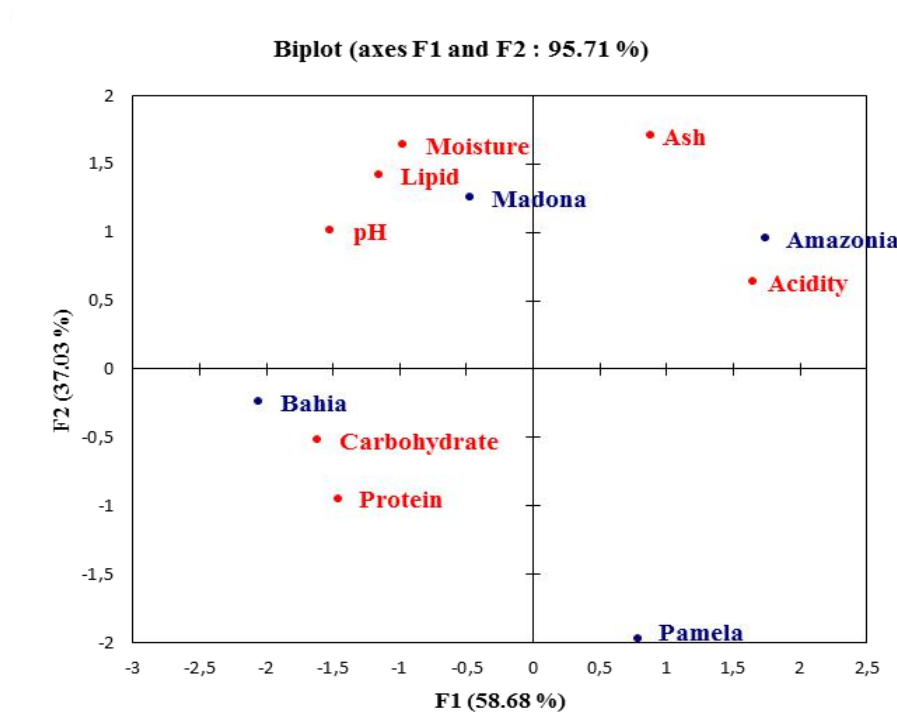| Parameters	F1	F2
Moisture	-0.5504	0.8275
pH	-0.8596	0.5099
Acidity	0.9312	0.3220
Carbohydrate	-0.9172	-0.2593
Protein	-0.8281	-0.4765
Lipid	-0.6524	0.7132
Ash	0.4959	0.8605

Fig. 1: Plan biplot of varieties of carrots and variable scores (PCA)