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Sensory quality and nutritional composition of carrot (*Daucus carota* L.) genotypes as affected by fertilization in production system in Cameroon

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Abstract

Background Recommendations for fertilizer use in agriculture do not take into account the growing region and the source of the organic matter. In addition, vegetable growers are unaware of the quantities of fertilizer to be applied during cultivation. Accordingly, there are increasing complaints about the poor quality of the vegetables produced which is likely associated to the type and the dose of fertilizer used. Therefore, the objective of this work was to determine the probable origin of poor carrot quality in production basins in Cameroon. The factors consisted of five carrot genotypes and nine fertilizer types arranged in the field in a split-split plot experimental design. The sensory quality of the carrot samples was assessed by a quantitative descriptive test. The nutritional value was determined according to the treatments performed.

Results The results of this study showed that both the sensory quality and nutritional value of carrots significantly depend on the variety, and the type and dose of fertilizer used. However, the variety *New Kuroda* treated with 10 t ha^{-1} of chicken manure and the unfertilized variety *Vanessa F1* were recorded as having the best sweetness and overall acceptability scores. The best nutrient parameters such as total carbohydrate, proteins, ash, cellulose, NDF and ADF were obtained with the carrot varieties *New Kuroda* grown with a combination of chemical fertilizer (300 kg ha^{-1}) + chicken manure (10 t ha^{-1}), *Pamela* + unfertilized, *Madona* fertilized with 10 t ha^{-1} chicken manure, with 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure or not fertilized, *Amazonia* fertilized with 300 kg ha^{-1} chemical fertilizer and *Vanessa F1* fertilized with a combination of 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} of chicken manure.

Conclusion Carrots with good sensory quality such as sweetness and deep orange colour were obtained with unfertilized *Vanessa* F1 variety. The variety *Amazonia* fertilized with 300 kg ha^{-1} chemical fertilizer provided good nutritional parameters including carotenoids, fibres, carbohydrates proteins and lipids.

Keywords Carrot genotype, Fertilizer, Nutritional value, Sensory quality

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Background

The consumption and marketing of fruits and vegetables are growing exponentially worldwide due to their attractive sensory properties and their recognized nutritional and therapeutic values (Ayala-Zavala et al. 2011; Silva et al. 2014). Being important for human nutrition, those fruits and vegetables in parallel to providing dietary fibre, also provide many minerals, vitamins and antioxidant compounds such as phenols and carotenoids (Augspole et al. 2014). Among these fruits and vegetables, carrots (*Daucus carota* L. fam Apiaceae) rank 10th in terms of nutritional value (Alasalvar et al. 2001). As a result, they are increasingly consumed because of their richness in carotenoids (provitamin A) which are important for eye health (Swamy et al. 2014). These vegetables are widely cultivated in the world with yields exceeding 40 million tonnes per hectare (FAOSTAT 2020).

However, carrot production in many countries is done using improved varieties to obtain high yields and consequent economic gains. But farmers often use fertilizers at excessive doses (Stewart et al. 2005; Dauda et al. 2008). This misapplication may be due to ignorance of the specific requirements of crops and new production methods (Muendo 2004). Indeed, according to Yield 2013, there is no exact recommendation for the use of organic fertilizers because their chemical composition differs depending on the sources of the materials used and the rate of nutrient release. In view of this ambiguity, chemical fertilizers are used because of their known nutrient supply and their ability to increase crop yields. However, the common use of chemical fertilizers, pesticides or any other synthetic preparations in carrot production, has reduced the carrots quality (Arisha and Bardisi 1999; Agbede et al. 2017).

However, consumer choice is often based on the perceived sensory and nutritional qualities of carrots when eaten raw in salads or boiled in meals (Win 2010). These qualities are influenced by several factors including genetic, edaphic and cultural factors (Anal 2013). Indeed, many studies have shown that the choice of variety and cultivation practices can significantly affect the taste and nutritional value of carrots before they reach consumers (Win 2010; Singh et al. 2012). Prominent among these studies is the work of Wrzodak et al. (2012) who found that sensory quality of carrots such as flavour, odour and overall acceptability significantly differ when using organic and conventional system. (Yield 2013) established that compost and livestock dung significantly increased the contents of total soluble solids, sugars and proteins of carrots. (Djoufack 2018) obtained a better sweetness of carrots using chicken manure. They also proved that the application of chicken manure, compost alone or in combination with chemical fertilizer increased the nutritional characteristics of carrots. (Coulibaly et al. 2018; Boadi et al. 2021) revealed following their studies that proteins, carbohydrates, lipids, fibres and ash in carrot depend on the genotype grown. (Hamadou et al. 2022) concluded that fertilizers, by stimulating nutrient biosynthesis, improve the nutritional quality of carrots. Therefore, growing carrots in a way that best preserves these qualities and respects the environment can be of great benefit to both socio-economic and food security. Considering all the above-mentioned work in this field of research, the assertion by Allemann and Young (2002) is prominent, according to which the appearance (size and shape) of carrot roots and the levels of nutrients they contain depend on the amount of nutrients in the soil. This assertion thus emphasizes the need to improve soil fertility (Appiah et al. 2017). Based on the above assertions, it can be said that the use of different types of fertilizers and carrot varieties leads to crop products with different sensory properties and nutrient contents, and this may also depend on the geographic region where the carrots are being grown. Thus, since the above-mentioned studies did not take into account the types of fertilizers, the doses applied and the types of carrot varieties, growing carrots with good organoleptic qualities and good nutritional value remains a concern for farmers, especially because they receive an increasing demand from consumers. Hence, the present study aimed at determining the effect of production systems used by Cameroonian farmers on the sensory qualities and nutritional value of carrots.

Methods

Plant material and description of the experimental site

The seeds of the carrot varieties used in this experimental trial were selected on the basis of a survey conducted among carrot producers in different production basins in Cameroon. At the end of this survey, five (05) varieties of carrot seeds named *New Kuroda*, *Pamela+*, *Madona*, *Amazonia*, and *Vanessa F1* were recorded as being predominantly grown and constituted the plant material for this experimental trial. The experimental trial was carried out during the main rainy season in the Western region of Cameroon between May and August 2021 at the Bansoa Application and Research Farm of the Faculty of Agronomy and Agricultural Sciences of the University of Dschang (5°28′00″0.1N, 10°15′57.5″E).

Sampling and analysis of soil and chicken manure

The determination of the physico-chemical characteristics of the experimental soil and the chemical composition of the chicken manure was done before the application of the fertilizers. Soil samples were taken randomly from different points at a depth of 0–20 cm. Samples from each point of the experimental site were pooled, air-dried and sub-sampled for analysis at the Soil Laboratory of the Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon. Soil pH was measured with a glass electrode (pH meter, pHep®, HANNA Instruments) according to IITA (International Institute of tropical Agriculture). Selected Methods for Soil and Plant Analysis (1979) methods. Soil organic matter was determined by the wet burning method as described by Walkey and Black (1934). The percentage of total nitrogen was determined by the micro-Kjeldahl technique described by Jackson (1958). The exchangeable cations, calcium, magnesium, potassium and sodium were determined as recommended by IITA (International Institute of tropical Agriculture). Selected Methods for Soil and Plant Analysis (1979) using EDTA titration after extraction with 0.1N ammonium acetate at pH 7. However, in order to have a benchmark for the application of fertilizer doses according to the nature of the soil, the bulk density of the soil was determined by the cylinder (C) field measurement method described by Yoro and Godo (1990). The properties of the soil and chicken manure determined are presented in Table 1.

Treatments and execution of the trial

The experimental site was ploughed to a depth of 40 cm to allow the good root development of the carrots. The doses of fertilizers applied were chosen on the basis of the bulk density value (determined in Kg m^{-3}) of the experimental soil. However, for each type of fertilization on every specific variety, a control consisting of an experimental unit without fertilizer was made. Each treatment was repeated 3 times and spread over three trial blocks. Fertilizers consisted of chicken manure and chemical fertilizer (NPK: 20-10-10), which were recorded as being the most commonly used fertilizers in carrot production in Cameroon. Fertilization consisted of E1F1: control; E1F2: 5 t ha^{-1} chicken manure; E1F3: 10 t ha^{-1} chicken manure; E2F1: 300 kg ha^{-1} chemical fertilizer; E2F2: 300 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure; E2F3: 300 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure; E3F1: 600 kg ha^{-1} chemical fertilizer; E3F2: 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure; E3F3: 600 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure. The chicken manure was applied seven (07) days before sowing. For a total of one hundred and thirty-five experimental units or forty-five observations per replication. The experimental units were arranged in a split-split plot design with chemical fertilizer as the primary factor, laying hen manure as a secondary factor and carrot variety as a tertiary factor.

Table 1 Physico-chemical analyses of experimental soil and chicken manure

Soil characteristics	Values	Chemical properties of chicken manure	Values
Clay (%)	21.00 ± 2.65	pH	7.1
Silt (%)	20.00 ± 3.46	N (%)	0.63
Sand (%)	59.00 ± 1.00	P (%)	0.97
Textural class	Sandy-clay	K (%)	4.56
pH water	6.57 ± 0.15	Ca (mg/Kg)	5760
pKCl	5.50 ± 0.10	Mg (mg/Kg)	11,615.4
OC (%)	3.90 ± 1.04		
OM (%)	6.73 ± 1.79		
Total N (%)	0.16 ± 0.04		
C/N	24.54 ± 2.39		
Ca (meq %)	3.71 ± 0.67		
Mg (meq %)	1.72 ± 0.84		
K (meq %)	1.25 ± 0.66		
Na (meq %)	0.64 ± 0.24		
CEC (meq %)	18.33 ± 2.66		

OC organic carbon, *OM* organic matter, *CEC* cation exchange capacity

The three blocks were separated from each other by a distance of 150 cm and the experimental units by a distance of 50 cm. Each experimental unit was 2 m^2 (2 m × 1 m) and consisted of 10 rows. The distance between two adjacent rows was 20 cm and 3 cm separated plants within rows. This results a sowing density of 1,200,000 plants per hectare. After hypocotyl formation and appearance of the first leaves, thinning between carrot plants was carried out for good root development. At the end of this thinning stage, the density of plants remaining on each experimental unit was on average 120 plants per 2 m^2. Weeds were removed manually as soon as they appeared to avoid competition for soil nutrients with carrot plants. The harvest period was justified by the appearance of signs of maturity such as leaf senescence and cracking of the carrot roots that took place at around 110 days after sowing.

Determination of the sensory quality of harvested carrots

Sample preparation

The carrot samples for the sensory quality evaluation were collected in the field on the day of the test. In order to avoid sensory fatigue due to the large number of samples (45 samples), nine carrot samples per day were presented to the panellists during the five days of the evaluation. The type of sensory analysis used was quantitative descriptive analysis according to the slightly modified method of Wrzodak et al. (2012). Approximately 3 cm of the root tip was removed, and the leaf tip located 0.5 cm below the green zone was cut off. The remaining parts of the carrot roots were then washed, peeled using a carrot peeler and sliced into approximately 2 cm slices using a slicing machine. The carrot slices were carefully mixed with each other and by separate treatment. The slices were distributed to the panellists in 150 ml plastic cups coded with a three-digit random number. This distribution of carrots to panellists was done in two replicates.

Panel constitution

The panellists were students trained in sensory evaluation and working on research topics related to sensory evaluation at the Research Unit of Biochemistry and Medicinal Plants, Food Science and Nutrition of the University of Dschang in Cameroon. Another group of panellists with no prior training in descriptive analysis also participated. A total of twelve (6 males and 6 females) panellists aged 23–30 years old participated in the study. To be enrolled, panellists had to pass a series of tests, including understanding and mastering the sensory descriptors used in the test. From the results of the test, 10 panellists were fit to participate in the study. They were not allergic to the product under evaluation and were available for all training and testing sessions. Prior to testing, verbal consent was obtained from each panellist.

Training of the panel

Panellists were trained for 2 h each day for 2 days on the intensity scale. During the training, they individually developed a list of descriptors that they could understand and apply consistently while evaluating raw carrot samples. After discussion, they collectively agreed on a list of attributes (Table 2). These attributes included: smell, orange colour, flavours and textures. The intensity of all descriptors (excepted the preference) was assessed on a continuous unstructured graphical scale ranging from 0 to 10 corresponding to each boundary term as proposed by Wrzodak et al. (2012). It was verbally agreed by the panellists during the training sessions that the left end of the scale corresponded to the lowest intensity (value 0) and the right end to the highest intensity of the attribute (value 10). The preference scale was structured from 1 (I do not like strongly) to 6 (I like strongly) as described by Peryam and Pilgrim (1957) slightly modified. The others scale were: 2 (I do not like moderately), 3 (I neither like nor dislike), 4 (I like moderately) and 5 (I like). Panellists assessed each carrot sample in a monadic sequential balanced order (one at a time). Scorecards for each sample presented during the test were provided in the order of the attributes listed.

Descriptive analysis

All trials were conducted in a sensory laboratory under white incandescent lighting. Panellists were instructed to taste two slices of carrot to assess flavour attributes and to taste the remaining slice to assess textural properties. Nine samples were evaluated in each session, for a total of 45 samples over five days. Panellists rinsed their mouths with room temperature mineral water between samples and had a mandatory 3 min break between samples. The carrot samples were evaluated and scored for odour, colour, as well as flavour intensity, texture and preference.

Determination of the chemical composition of core samples

The various chemical analyses were carried out using different methods and the results were expressed as a percentage of dry matter. The percentage of moisture and ash contents were determined by the method described by AOAC 1990; the protein and lipid contents were respectively determined by the Kjeldhal method described by AOAC 1990 and (Bourely 1982). The total carbohydrate content was determined by difference

Table 2 Sensory quality descriptors used in the evaluation of fresh carrot roots and their definitions

Quality descriptors	Definition	Boundary terms
Carrot smell	The characteristic smell of raw carrot	Imperceptible (0)- Very intense (10)
Mild odour	Positive impression when sniffing the carrot sample	Imperceptible (0)—Very intense (10)
Outer skin colour	Visual assessment of skin colour intensity	Light orange (0)—Dark orange (10)
Colour of the longitudinal section of the root	Visual assessment of root section colour	Light orange (0)—Dark orange (10)
Crispness of the flesh	The intensity of the sound heard when biting the sample with the front teeth	No sound (0)—Very noisy (10)
Hardness of the flesh	The force required to crush the sample with the molars	Soft (0)—Hard (10)
Crunchiness of the flesh	Repetitive noises when chewing the sample with the molars	Short sound (0)—Long and loud sound (10)
Flesh juice	The impression of a free-flowing juice when crushing a piece of carrot	No juice (0)—Very juicy (10)
Sweetness	Basic taste	Imperceptible (0)—Very intense (10)
Earthy taste	Aromatic characteristics of the wetland	Imperceptible (0)—Very intense (10)
Overall quality score	Overall impression covering all quality descriptors	Poor quality (0)—Very good quality (10)
Preference	Feeling after evaluation of core samples	I do not like strongly (1)—I like strongly (6)

according to the method described by AOAC 1990. The content of reducing sugars was determined by the reduction of DNS (3,5dinitrosalicylic acid) according to the method of Fischer and Stein (1961). The total carotenoids content was determined by the method described by Rodriguez-Amaya and Kimura 2004 with slight modification. NDF (Neutral Detergent Fibre), ADF (Acid Detergent Fibre) and ADL (Acid Detergent Lignin) contents were determined according to the methods of Soest et al. (1991). Hemicellulose and cellulose were calculated by difference as NDF—ADF and ADF—ADL respectively (Rinne et al. 1997).

Statistical analysis

Data of nutrient parameters and sensory evaluation, expressed as means, were subjected to two-way analysis of variance (Fertilizers and varieties) using the XLSTAT 2016 software version 2. This analysis of variance was applied after ensuring a normal distribution and homogeneity of variances. When a significant difference was found, Tukey HSD test at 5% probability threshold for effect of interactions (fertilization and variety), was applied to separate the means of different treatments. Using the same software, Principal component analysis was performed on the nutrient parameters to evaluate the different correlations existing between the determined variables and to select the combination of fertilizers and varieties that allowed the best values of the measured parameters to be obtained. Pearson's correlation test was performed between nutrient parameters and sensory attributes at 5% significance level. This was done to predict the effects of nutrient variables on sensory variables.

Results

Influence of fertilizer and variety on the sensory qualities of harvested carrot roots

From the twelve sensory parameters analysed, three (carrot mild odour, sweetness and preference) were significantly affected ($p < 0.05$) by the fertilization (Table 3). Samples grown without fertilization (E1F1) showed a significantly higher mild odour (5.98 ± 1.70) and sweetness (5.74 ± 1.79) than the samples treated with 600 kg ha^{-1} of chemical fertilizers (E3F1) (4.68 ± 0.47 and 4.36 ± 0.99 respectively). As the study of preference was carried out in this work, the samples least preferred by the panellists were those grown with chemical fertilizer at doses of 300 kg ha^{-1} (E2F1) and 600 kg ha^{-1} (E3F1) and the most preferred was the untreated one (E1F1).

Mean scores recorded when evaluating the effect of varieties on twelve sensory parameters were presented in Table 3. All sensory parameters were significantly affected ($p < 0.05$) by the variety. For carrot odour, the highest score was obtained with *Amazonia* (5.97 ± 0.25) and the lowest one with *Vanessa F1* (4.73 ± 0.85). With regard to the orange colour of the carrot root skin, the variety *New Kuroda* recorded the highest score (6.89 ± 1.44) and the variety *Pamela+* recorded the lowest score (3.44 ± 0.97). However, no significant difference in orange skin colour of the samples was recorded between the varieties *Madona* (6.05 ± 1.57), *Amazonia* (6.12 ± 1.27) and *Vanessa F1* (5.79 ± 1.04). Considering the orange colour of the longitudinal section, the varieties *New Kuroda* and *Amazonia* obtained the highest scores (6.86 ± 1.30 and 6.47 ± 1.14 respectively) compared to the other varieties while the variety *Pamela+* recorded the lowest score (3.34 ± 1.16). For sweetness, the varieties *Vanessa F1*, *New Kuroda* and *Pamela+* recorded the highest scores (5.81 ± 1.41, 5.40 ± 2.08 and 5.19 ± 1.55 respectively) while *Madona* was recorded as the variety with the lowest score (3.66 ± 0.34). As for hardness, the varieties *Madona* (5.16 ± 1.82), *Amazonia* (5.53 ± 1.45) and *Vanessa F1* (5.09 ± 1.22), were recorded as harder than the variety *New Kuroda* (4.33 ± 2.48). Of the varieties studied, the crispiest were *New Kuroda* (6.29 ± 2.13) and *Pamela+* (6.14 ± 1.49). *New Kuroda* scored the highest (6.01 ± 2.20) significantly ahead of *Vanessa F1* (4.81 ± 1.09) and *Amazonia* (5.27 ± 1.11) for the crispness descriptor. In general, the varieties *New Kuroda*, *Pamela+* and *Vanessa F1* showed the best overall acceptability and preference scores.

Table 3 presents the interaction of fertilization and variety on the sensory qualities evaluated. The analysis of the scores of the obtained descriptors allowed to observe significant differences ($p < 0.05$) within the parameters such as carrot odour, sweetness, orange coloration of the skin and longitudinal section, overall score and preference. However, no significant difference was recorded when evaluating descriptors such as Earthy taste, Hardness, Crispness, Crunchiness and Juiciness. For the carrot odour descriptor, no significant effect of fertilizers was observed on each variety. Nevertheless, the unfertilized variety *Madona* presented a significantly higher score (6.90 ± 1.10) than the score obtained with *Pamela+* treated with 300 kg ha^{-1} of chemical fertilizer (3.90 ± 1.10). Regarding mild odour, the effects of fertilizers within each variety are non-significant. Comparing the interactions, *Madona* treated with 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E2F2) recorded a significantly higher score (6.90 ± 1.52) compared to *New Kuroda* (2.34 ± 1.52) that received the same type of fertilizer. Comparing the scores obtained after evaluation of the effects of fertilizers on the carrot varieties with the scores obtained with the controls, for the orange colour of the skin and of the longitudinal section, no fertilizer significantly affected these descriptors.

Table 3 Influence of fertilization and variety on sensory parameters of carrot samples

Parameters	**Fertilizers**										
	Varieties	**E1F1**	**E1F2**	**E1F3**	**E2F1**	**E2F2**	**E2F3**	**E3F1**	**E3F2**	**E3F3**	**Means**
Carrot smell	*New Kuroda*	6.40 ± 2.01^{abc}	6.40 ± 1.34^{abc}	5.80 ± 2.14^{abc}	5.70 ± 1.41^{abc}	5.10 ± 2.33^{abc}	5.60 ± 2.45^{abc}	5.30 ± 1.70^{abc}	4.80 ± 1.54^{abc}	6.80 ± 1.68^{ab}	5.76 ± 1.90^{AB}
	Pamela +	5.300 ± 1.33^{abc}	5.90 ± 1.79^{abc}	4.40 ± 2.01^{abc}	3.90 ± 1.10^{c}	5.50 ± 2.71^{abc}	5.40 ± 1.95^{abc}	5.60 ± 1.83^{abc}	6.00 ± 1.49^{abc}	5.80 ± 1.47^{abc}	5.31 ± 1.84^{BC}
	Madona	6.90 ± 1.10^{a}	6.40 ± 1.71^{abc}	5.65 ± 1.63^{abc}	5.60 ± 1.07^{abc}	6.40 ± 1.71^{abc}	5.10 ± 1.96^{abc}	5.90 ± 1.66^{abc}	5.50 ± 2.01^{abc}	5.40 ± 0.96^{abc}	5.87 ± 1.60^{AB}
	Amazonia	6.40 ± 1.07^{abc}	6.50 ± 1.77^{abc}	6.60 ± 1.71^{abc}	5.50 ± 1.35^{abc}	6.10 ± 1.28^{abc}	6.10 ± 1.52^{abc}	5.10 ± 1.37^{abc}	5.40 ± 1.07^{abc}	6.00 ± 1.56^{abc}	5.97 ± 0.25^{A}
	Vanessa F1	5.60 ± 1.07^{abc}	5.30 ± 0.82^{abc}	4.90 ± 0.73^{abc}	4.70 ± 0.94^{abc}	4.60 ± 0.69^{abc}	4.60 ± 0.84^{abc}	4.10 ± 0.56^{bc}	4.30 ± 0.48^{abc}	4.50 ± 0.52^{abc}	4.73 ± 0.85^{C}
	Means	6.12 ± 1.43^{A}	5.70 ± 1.68^{A}	5.47 ± 1.81^{A}	5.48 ± 1.35^{A}	5.54 ± 1.92^{A}	5.36 ± 1.82^{A}	5.20 ± 1.56^{A}	5.20 ± 1.48^{A}	5.70 ± 1.47^{A}	
Mild odour	*New Kuroda*	5.00 ± 2.00^{abc}	4.30 ± 1.94^{abc}	4.90 ± 1.52^{abc}	3.80 ± 1.54^{bc}	3.20 ± 2.34^{c}	4.00 ± 2.00^{abc}	3.70 ± 1.82^{bc}	3.80 ± 2.25^{bc}	5.00 ± 2.26^{abc}	4.18 ± 1.99^{B}
	Pamela +	6.10 ± 1.37^{abc}	3.90 ± 2.18^{abc}	3.90 ± 2.18^{abc}	6.20 ± 1.31^{abc}	5.50 ± 2.17^{abc}	6.50 ± 1.43^{ab}	5.40 ± 1.42^{abc}	5.20 ± 2.09^{abc}	5.80 ± 2.25^{abc}	5.39 ± 1.99^{A}
	Madona	6.00 ± 2.35^{abc}	6.00 ± 2.21^{abc}	4.80 ± 1.87^{abc}	5.70 ± 2.00^{abc}	6.90 ± 1.52^{a}	5.40 ± 2.17^{abc}	4.90 ± 1.59^{abc}	4.50 ± 2.22^{abc}	4.60 ± 2.01^{abc}	5.42 ± 2.06^{A}
	Amazonia	6.40 ± 1.50^{ab}	6.10 ± 2.02^{abc}	6.10 ± 1.96^{abc}	4.80 ± 1.31^{abc}	5.30 ± 1.49^{abc}	5.50 ± 0.97^{abc}	5.00 ± 1.15^{abc}	5.30 ± 1.49^{abc}	5.00 ± 1.49^{abc}	5.50 ± 1.55^{A}
	Vanessa F1	6.40 ± 0.84^{ab}	6.20 ± 0.78^{abc}	5.70 ± 0.94^{abc}	4.70 ± 0.82^{abc}	4.50 ± 0.97^{abc}	4.50 ± 0.70^{abc}	4.40 ± 0.84^{abc}	4.80 ± 0.78^{abc}	5.20 ± 0.78^{abc}	5.16 ± 1.08^{A}
	Means	5.98 ± 1.70^{A}	5.30 ± 2.08^{AB}	5.08 ± 1.84^{AB}	5.04 ± 1.62^{AB}	5.08 ± 2.09^{AB}	5.18 ± 1.73^{AB}	4.68 ± 0.47^{B}	4.72 ± 1.86^{B}	5.12 ± 1.81^{AB}	
Skin colour	*New Kuroda*	7.20 ± 0.63^{a}	6.80 ± 1.54^{ab}	6.00 ± 1.15^{abc}	7.00 ± 1.63^{ab}	7.10 ± 1.37^{ab}	6.90 ± 1.79^{ab}	7.10 ± 1.72^{ab}	6.60 ± 1.64^{ab}	7.30 ± 1.33^{a}	6.89 ± 1.44^{A}
	Pamela +	3.10 ± 0.99^{h}	3.40 ± 0.84^{fgh}	3.30 ± 1.05^{gh}	3.60 ± 0.84^{defgh}	3.60 ± 1.07^{defgh}	3.50 ± 1.35^{efgh}	3.80 ± 0.78^{cdefgh}	3.30 ± 0.94^{gh}	3.40 ± 0.96^{fgh}	3.44 ± 0.97^{C}
	Madona	6.30 ± 1.15^{ab}	7.60 ± 0.96^{a}	6.50 ± 1.58^{ab}	5.60 ± 1.34^{abcdef}	5.90 ± 1.66^{abc}	6.65 ± 1.45^{ab}	5.40 ± 1.34^{abcdefg}	4.90 ± 1.79^{bcdefgh}	5.60 ± 1.50^{abcdef}	6.05 ± 1.57^{B}
	Amazonia	6.40 ± 0.63^{ab}	5.60 ± 0.84^{abcdef}	5.80 ± 1.03^{abcd}	6.40 ± 1.71^{ab}	6.60 ± 1.57^{ab}	6.80 ± 1.47^{ab}	5.80 ± 1.22^{abcd}	6.00 ± 1.24^{abc}	5.70 ± 1.15^{abcde}	6.12 ± 1.27^{B}
	Vanessa F1	6.00 ± 1.33^{abc}	5.80 ± 1.31^{abcd}	5.70 ± 1.25^{abcde}	5.50 ± 0.52^{abcdefg}	5.80 ± 0.78^{abcd}	5.60 ± 0.84^{abcdef}	5.90 ± 1.37^{abc}	5.80 ± 1.13^{abcd}	6.00 ± 0.81^{abc}	5.79 ± 1.04^{B}
	Means	5.80 ± 1.71^{A}	5.84 ± 1.79^{A}	5.46 ± 1.63^{A}	5.62 ± 1.70^{A}	5.80 ± 1.76^{A}	5.89 ± 1.87^{A}	5.60 ± 1.66^{A}	5.32 ± 1.76^{A}	5.60 ± 1.70^{A}	
Colour of the longitudinal section	*New Kuroda*	7.00 ± 1.15^{ab}	6.10 ± 1.59^{abcde}	6.50 ± 1.08^{abcd}	7.10 ± 1.52^{ab}	7.00 ± 0.67^{ab}	7.00 ± 1.33^{ab}	7.10 ± 1.44^{ab}	6.80 ± 1.39^{abc}	7.10 ± 1.44^{ab}	6.86 ± 1.30^{A}
	Pamela +	3.50 ± 0.97^{ghij}	3.80 ± 1.13^{fghij}	2.80 ± 1.03^{j}	3.00 ± 1.56^{ij}	3.50 ± 0.97^{ghij}	3.30 ± 1.33^{hij}	3.90 ± 0.87^{efghij}	3.50 ± 0.97^{ghij}	2.80 ± 1.31^{j}	3.34 ± 1.16^{C}
	Madona	5.80 ± 0.91^{abcdef}	7.20 ± 1.47^{a}	6.60 ± 1.57^{abcd}	$4.90 \pm 1.28^{bcdefghij}$	5.55 ± 1.64^{abcdefgh}	6.40 ± 1.50^{abcd}	$5.20 \pm 2.14^{abcdefghi}$	4.60 ± 1.64^{cdefghij}	4.50 ± 1.43^{defghij}	5.64 ± 1.72^{B}
	Amazonia	6.70 ± 1.05^{abcd}	6.40 ± 1.07^{abcde}	6.10 ± 1.59^{abcde}	6.10 ± 1.52^{abcd}	6.20 ± 1.03^{abcd}	6.40 ± 0.96^{abc}	6.80 ± 1.39^{abc}	6.80 ± 0.78^{abcd}	6.70 ± 0.67^{abcd}	6.47 ± 1.14^{A}
	Vanessa F1	6.30 ± 1.56^{abcd}	6.30 ± 1.41^{abcd}	6.20 ± 1.39^{abcd}	5.70 ± 0.94^{abcdefg}	5.90 ± 0.87^{abcdef}	6.10 ± 0.99^{abcde}	5.40 ± 0.84^{abcdefgh}	5.40 ± 0.69^{abcdefgh}	5.90 ± 0.87^{abcdef}	5.91 ± 1.10^{B}
	Means	5.86 ± 1.67^{A}	5.96 ± 1.73^{A}	5.64 ± 1.94^{A}	5.36 ± 1.92^{A}	5.63 ± 1.57^{A}	5.84 ± 1.77^{A}	5.68 ± 1.80^{A}	5.42 ± 1.70^{A}	5.40 ± 1.95^{A}	
Sweetness	*New Kuroda*	5.30 ± 2.11^{abcd}	5.50 ± 2.32^{abcd}	5.80 ± 1.54^{abcd}	5.30 ± 1.63^{abcd}	5.60 ± 2.71^{abcd}	5.80 ± 2.09^{abcd}	4.70 ± 2.79^{abcdef}	$4.80\ 1.61 \pm{}^{abcdef}$	5.80 ± 2.09^{abcd}	5.40 ± 2.08^{AB}
	Pamela +	5.30 ± 0.48^{abcd}	4.60 ± 1.17^{bcdef}	5.30 ± 1.25^{abcd}	5.80 ± 1.47^{abcd}	5.10 ± 1.85^{abcde}	5.40 ± 1.42^{abcd}	5.60 ± 1.71^{abcd}	4.50 ± 2.46^{bcdef}	5.10 ± 1.59^{abcde}	5.19 ± 1.55^{AB}
	Madona	5.20 ± 2.14^{abcd}	4.10 ± 2.07^{cdef}	4.00 ± 2.74^{cdef}	3.80 ± 2.44^{def}	3.50 ± 2.75^{def}	3.60 ± 2.71^{def}	4.60 ± 1.77^{bcdef}	2.10 ± 1.37^{ef}	2.00 ± 1.49^{f}	3.66 ± 0.34^{C}
	Amazonia	5.20 ± 1.61^{abcd}	4.70 ± 1.05^{abcdef}	4.60 ± 1.07^{bcdef}	4.70 ± 1.33^{abcdef}	4.70 ± 0.82^{abcdef}	4.80 ± 1.39^{abcdef}	4.60 ± 1.57^{bcdef}	4.80 ± 1.47^{abcdef}	4.80 ± 1.75^{abcdef}	4.77 ± 1.32^{B}
	Vanessa F1	7.70 ± 0.48^{a}	6.90 ± 0.73^{abc}	7.20 ± 0.91^{ab}	4.60 ± 0.69^{bcdef}	4.50 ± 0.70^{bcdef}	4.70 ± 0.67^{abcdef}	5.10 ± 1.10^{abcde}	5.60 ± 1.07^{abcd}	6.00 ± 1.15^{abcd}	5.81 ± 1.41^{A}
	Means	5.74 ± 1.79^{A}	5.16 ± 1.82^{AB}	5.38 ± 1.92^{AB}	4.84 ± 1.69^{AB}	4.68 ± 2.02^{AB}	4.86 ± 1.88^{AB}	4.36 ± 0.99^{B}	4.92 ± 1.83^{AB}	4.74 ± 2.14^{AB}	
Earthy taste	*New Kuroda*	2.30 ± 2.90^{a}	2.70 ± 3.02^{a}	2.20 ± 2.44^{a}	2.60 ± 2.98^{a}	2.00 ± 2.53^{a}	2.50 ± 3.37^{a}	3.00 ± 2.53^{a}	2.20 ± 2.39^{a}	2.50 ± 2.99^{a}	2.44 ± 2.70^{A}
	Pamela +	0.90 ± 2.18^{a}	1.10 ± 1.85^{a}	1.20 ± 1.61^{a}	0.70 ± 1.05^{a}	1.00 ± 2.49^{a}	0.40 ± 0.69^{a}	1.10 ± 1.96^{a}	0.80 ± 1.31^{a}	0.90 ± 1.72^{a}	0.90 ± 1.67^{B}
	Madona	1.20 ± 2.52^{a}	0.60 ± 1.34^{a}	1.20 ± 1.61^{a}	1.20 ± 2.29^{a}	0.30 ± 0.67a	1.10 ± 2.13^{a}	0.40 ± 0.84^{a}	1.10 ± 2.51^{a}	1.30 ± 1.63^{a}	0.93 ± 1.80^{B}
	Amazonia	0.30 ± 0.67^{a}	0.40 ± 0.96^{a}	0.60 ± 0.96^{a}	0.30 ± 0.67^{a}	0.40 ± 0.51^{a}	0.30 ± 0.48^{a}	0.30 ± 0.48^{a}	0.50 ± 0.71^{a}	0.50 ± 0.71^{a}	0.40 ± 0.68^{BC}
	Vanessa F1	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	$0.00\ 0.00^{a}$	0.00 ± 0.00^{a}	0.00 ± 0.00^{C}
	Means	0.94 ± 2.08^{A}	0.96 ± 1.92^{A}	1.04 ± 1.66^{A}	0.96 ± 1.93^{A}	0.74 ± 1.72^{A}	0.86 ± 1.96^{A}	0.96 ± 1.80^{A}	0.92 ± 1.78^{A}	1.04 ± 1.87^{A}	

Table 3 (continued)

Parameters	Fertilizers										
	Varieties	E1F1	E1F2	E1F3	E2F1	E2F2	E2F3	E3F1	E3F2	E3F3	Means
Hardness	*New Kuroda*	4.50 ± 2.54^{a}	3.50 ± 2.36^{a}	4.10 ± 2.80^{a}	4.10 ± 2.42^{a}	4.90 ± 2.17^{a}	4.30 ± 2.31^{a}	4.10 ± 2.60^{a}	5.20 ± 2.25^{a}	4.30 ± 2.90^{a}	4.33 ± 2.48^{B}
	Pamela +	4.90 ± 0.73^{a}	5.30 ± 1.41^{a}	4.80 ± 1.54^{a}	4.90 ± 1.52^{a}	4.90 ± 2.02^{a}	5.10 ± 2.33^{a}	4.90 ± 1.59^{a}	5.10 ± 1.10^{a}	4.40 ± 1.89^{a}	4.92 ± 1.58^{AB}
	Madona	5.60 ± 1.95^{a}	4.70 ± 2.16^{a}	4.90 ± 1.91^{a}	5.10 ± 1.52^{a}	5.30 ± 1.63^{a}	5.30 ± 1.94^{a}	5.30 ± 1.82^{a}	5.10 ± 1.79^{a}	5.10 ± 2.18^{a}	5.16 ± 1.82^{A}
	Amazonia	5.10 ± 1.37^{a}	5.20 ± 1.54^{a}	5.60 ± 1.34^{a}	5.80 ± 1.03^{a}	6.00 ± 1.41^{a}	6.70 ± 1.25^{a}	5.20 ± 1.68^{a}	5.00 ± 1.49^{a}	5.20 ± 1.54^{a}	5.53 ± 1.45^{A}
	Vanessa F1	5.50 ± 0.97^{a}	5.60 ± 0.96^{a}	5.00 ± 0.67^{a}	4.90 ± 1.28^{a}	4.80 ± 1.61^{a}	4.70 ± 1.41^{a}	4.50 ± 0.97^{a}	5.10 ± 1.37^{a}	5.70 ± 1.33^{a}	5.09 ± 1.22^{A}
	Means	5.12 ± 1.63^{A}	4.86 ± 1.85^{A}	4.88 ± 1.79^{A}	4.96 ± 1.65^{A}	5.18 ± 1.91^{A}	5.22 ± 2.00^{A}	4.80 ± 1.79^{A}	5.10 ± 1.58^{A}	4.94 ± 2.03^{A}	
Crispness	*New Kuroda*	6.50 ± 2.63^{a}	6.00 ± 2.00^{a}	6.20 ± 1.87^{a}	6.00 ± 1.76^{a}	6.80 ± 1.93^{a}	6.20 ± 2.52^{a}	6.40 ± 2.17^{a}	6.00 ± 2.00^{a}	6.50 ± 2.79^{a}	6.29 ± 2.13^{A}
	Pamela +	6.80 ± 1.39^{a}	6.10 ± 1.59^{a}	6.30 ± 1.63^{a}	6.20 ± 1.03^{a}	5.70 ± 1.70^{a}	5.70 ± 2.21^{a}	6.20 ± 1.31^{a}	6.20 ± 1.31^{a}	6.10 ± 1.28^{a}	6.14 ± 1.49^{A}
	Madona	5.40 ± 1.42^{a}	5.20 ± 1.75^{a}	4.50 ± 2.46^{a}	5.40 ± 2.06^{a}	5.30 ± 1.33^{a}	5.20 ± 2.14^{a}	5.10 ± 1.79^{a}	3.90 ± 2.28^{a}	4.70 ± 2.62^{a}	4.97 ± 1.99^{B}
	Amazonia	5.40 ± 1.42^{a}	5.00 ± 0.81^{a}	4.70 ± 1.33^{a}	5.10 ± 0.99^{a}	5.70 ± 1.70^{a}	5.40 ± 0.84^{a}	5.70 ± 1.49^{a}	4.70 ± 1.33^{a}	4.70 ± 1.76^{a}	5.16 ± 1.34^{B}
	Vanessa F1	5.70 ± 1.63^{a}	6.00 ± 0.94^{a}	5.60 ± 0.96^{a}	4.60 ± 1.42^{a}	4.70 ± 0.94^{a}	4.60 ± 1.07^{a}	4.50 ± 0.97^{a}	5.30 ± 1.05^{a}	5.70 ± 1.05^{a}	5.18 ± 1.22^{B}
	Means	5.96 ± 1.79^{A}	5.66 ± 1.50^{A}	5.46 ± 1.82^{A}	5.46 ± 1.56^{A}	5.64 ± 1.65^{A}	5.42 ± 1.88^{A}	5.58 ± 1.69^{A}	5.22 ± 1.81^{A}	5.54 ± 2.08^{A}	
Crunchy	*New Kuroda*	6.90 ± 2.13^{a}	6.70 ± 1.70^{a}	6.80 ± 1.61^{a}	5.70 ± 2.45^{a}	6.10 ± 2.07^{a}	5.60 ± 1.89^{a}	5.40 ± 2.50^{a}	5.10 ± 2.28^{a}	5.80 ± 2.93^{a}	6.01 ± 2.20^{A}
	Pamela +	5.60 ± 1.34^{a}	5.50 ± 1.17^{a}	5.50 ± 1.50^{a}	5.50 ± 1.50^{a}	6.30 ± 2.21^{a}	5.10 ± 2.07^{a}	5.70 ± 1.76^{a}	5.20 ± 1.68^{a}	5.20 ± 1.22^{a}	5.51 ± 1.60^{AB}
	Madona	6.60 ± 1.50^{a}	6.30 ± 1.41^{a}	6.10 ± 2.02^{a}	5.90 ± 1.66^{a}	5.30 ± 1.41^{a}	5.40 ± 2.06^{a}	5.70 ± 1.94^{a}	4.50 ± 2.27^{a}	6.00 ± 2.35^{a}	5.76 ± 1.89^{AB}
	Amazonia	5.20 ± 1.13^{a}	5.10 ± 1.28^{a}	5.10 ± 0.73^{a}	5.10 ± 1.28^{a}	5.90 ± 1.19^{a}	5.50 ± 1.17^{a}	5.10 ± 1.19^{a}	5.20 ± 0.91^{a}	5.20 ± 1.22^{a}	5.27 ± 1.11^{BC}
	Vanessa F1	5.00 ± 0.94^{a}	5.50 ± 0.97^{a}	5.30 ± 0.94^{a}	4.30 ± 1.05^{a}	4.10 ± 0.99^{a}	4.60 ± 0.96^{a}	4.60 ± 1.42^{a}	4.90 ± 0.99^{a}	5.00 ± 1.05^{a}	4.81 ± 1.09^{C}
	Means	5.86 ± 1.60^{A}	5.82 ± 1.40^{A}	5.76 ± 1.51^{A}	5.30 ± 1.69^{A}	5.54 ± 1.77^{A}	5.24 ± 1.67^{A}	5.30 ± 1.79^{A}	4.98 ± 1.58^{A}	5.44 ± 2.03^{A}	
Juicy	*New Kuroda*	4.70 ± 2.00^{a}	5.40 ± 1.42^{a}	4.70 ± 1.63^{a}	5.10 ± 1.66^{a}	5.70 ± 1.31^{a}	5.30 ± 1.88^{a}	6.20 ± 1.75^{a}	4.50 ± 1.71^{a}	5.00 ± 1.05^{a}	5.18 ± 1.74^{A}
	Pamela +	4.30 ± 1.05^{a}	4.50 ± 1.64^{a}	5.70 ± 1.05^{a}	5.30 ± 1.82^{a}	5.50 ± 1.50^{a}	4.60 ± 1.77^{a}	5.60 ± 1.71^{a}	5.30 ± 1.70^{a}	5.50 ± 1.84^{a}	5.14 ± 1.60^{A}
	Madona	4.80 ± 2.04^{a}	5.40 ± 1.64^{a}	4.70 ± 1.63^{a}	5.20 ± 2.04^{a}	4.40 ± 1.26^{a}	5.10 ± 1.96^{a}	4.90 ± 2.02^{a}	5.60 ± 1.83^{a}	5.70 ± 2.05^{a}	5.09 ± 1.81^{A}
	Amazonia	4.90 ± 1.28^{a}	4.70 ± 0.94^{a}	4.60 ± 0.69^{a}	5.00 ± 1.05^{a}	4.90 ± 1.79^{a}	4.90 ± 1.44^{a}	5.30 ± 1.05^{a}	5.20 ± 1.03^{a}	5.60 ± 1.42^{a}	5.01 ± 1.21^{A}
	Vanessa F1	5.90 ± 1.10^{a}	5.40 ± 1.07^{a}	5.00 ± 1.49^{a}	5.50 ± 1.50^{a}	5.50 ± 1.58^{a}	5.30 ± 1.15^{a}	5.00 ± 1.24^{a}	4.90 ± 1.37^{a}	4.80 ± 1.03^{a}	5.26 ± 1.28^{A}
	Means	4.92 ± 1.58^{A}	5.08 ± 1.38^{A}	4.94 ± 1.36^{A}	5.22 ± 1.59^{A}	5.20 ± 1.72^{A}	5.04 ± 1.62^{A}	5.40 ± 1.60^{A}	5.10 ± 1.54^{A}	5.32 ± 1.51^{A}	
Overall acceptability score	*New Kuroda*	6.00 ± 1.33^{abcd}	5.60 ± 1.64^{abcd}	5.80 ± 1.75^{abcd}	5.90 ± 1.19^{abcd}	5.90 ± 1.44^{abcd}	6.40 ± 1.34^{abcd}	6.60 ± 1.34^{abc}	5.70 ± 1.15^{abcd}	6.00 ± 1.49^{abcd}	5.99 ± 1.39^{A}
	Pamela +	5.60 ± 1.17^{abcd}	5.20 ± 1.13^{bcd}	5.60 ± 1.07^{abcd}	6.10 ± 0.99^{abcd}	5.80 ± 1.39^{abcd}	5.70 ± 1.56^{abcd}	6.30 ± 0.82^{abcd}	5.70 ± 0.82^{abcd}	5.40 ± 0.84^{abcd}	5.71 ± 1.11^{A}
	Madona	5.60 ± 2.11^{abcd}	5.20 ± 1.61^{bcd}	4.10 ± 2.42^{d}	5.50 ± 1.50^{abcd}	5.10 ± 2.07^{bcd}	5.70 ± 2.40^{abcd}	4.80 ± 2.25^{bcd}	4.40 ± 1.71^{cd}	4.50 ± 2.01^{cd}	4.99 ± 2.01^{B}
	Amazonia	5.60 ± 1.42^{abcd}	4.80 ± 1.22^{bcd}	4.90 ± 1.19^{bcd}	4.60 ± 0.69^{cd}	4.70 ± 0.94^{cd}	4.80 ± 1.31^{bcd}	5.10 ± 1.10^{bcd}	5.20 ± 0.78^{bcd}	5.60 ± 1.07^{abcd}	5.03 ± 1.11^{B}
	Vanessa F1	7.70 ± 0.94^{a}	7.20 ± 0.78^{ab}	6.80 ± 0.78^{abc}	5.10 ± 1.10^{bcd}	5.00 ± 1.15^{bcd}	4.90 ± 1.19^{bcd}	5.10 ± 0.87^{bcd}	5.50 ± 1.43^{abcd}	5.50 ± 1.08^{abcd}	5.87 ± 1.43^{A}
	Means	6.10 ± 1.61^{A}	5.60 ± 1.52^{A}	5.44 ± 1.08^{A}	5.44 ± 1.21^{A}	5.30 ± 1.47^{A}	5.50 ± 1.66^{A}	5.58 ± 1.51^{A}	5.30 ± 1.28^{A}	5.40 ± 1.39^{A}	

Table 3 (continued)

Parameters	Fertilizers										
	Varieties	**E1F1**	**E1F2**	**E1F3**	**E2F1**	**E2F2**	**E2F3**	**E3F1**	**E3F2**	**E3F3**	**Means**
Preference	*New Kuroda*	3.60 ± 1.26^{bcde}	3.80 ± 1.03^{bcde}	5.90 ± 1.79^{a}	3.10 ± 1.37^{de}	4.20 ± 1.39^{abcde}	4.40 ± 1.07^{abcde}	3.80 ± 1.75^{bcde}	4.30 ± 0.67^{abcde}	4.20 ± 1.13^{abcde}	4.14 ± 1.39^{AB}
	Pamela +	4.60 ± 0.69^{abcde}	4.10 ± 0.87^{bcde}	3.90 ± 0.99^{bcde}	4.20 ± 1.13^{abcde}	4.90 ± 0.73^{abc}	4.70 ± 0.94^{abcd}	4.30 ± 1.15^{abcde}	4.20 ± 1.13^{abcde}	4.40 ± 0.96^{abcde}	4.36 ± 0.97^{A}
	Madona	4.80 ± 0.63^{abcd}	3.80 ± 0.63^{bcde}	3.40 ± 1.26^{bcde}	4.10 ± 0.73^{bcde}	3.20 ± 1.54^{cde}	4.00 ± 1.49^{bcde}	4.30 ± 0.82^{abcde}	3.30 ± 1.25^{bcde}	2.90 ± 1.10^{e}	3.76 ± 1.20^{B}
	Amazonia	4.50 ± 0.70^{abcde}	4.00 ± 0.47^{bcde}	3.70 ± 0.67^{bcde}	4.00 ± 0.81^{bcde}	3.40 ± 0.51^{bcde}	3.40 ± 0.51^{bcde}	3.90 ± 0.87^{bcde}	4.00 ± 0.94^{bcde}	4.50 ± 0.97^{abcde}	3.93 ± 0.80^{B}
	Vanessa F1	5.00 ± 0.67^{ab}	4.70 ± 0.82^{abcd}	4.20 ± 0.78^{abcde}	3.20 ± 0.63^{cde}	3.40 ± 0.69^{bcde}	3.30 ± 0.82^{bcde}	3.20 ± 0.78^{cde}	3.30 ± 0.67^{bcde}	3.60 ± 0.84^{bcde}	3.77 ± 0.97^{B}
	Means	4.50 ± 0.93^{A}	4.08 ± 0.82^{ABC}	4.28 ± 1.26^{AB}	3.66 ± 1.75^{C}	3.82 ± 1.20^{BC}	3.96 ± 1.12^{ABC}	3.82 ± 1.02^{BC}	3.90 ± 1.16^{ABC}	3.92 ± 1.13^{ABC}	

E1F1 control, *E1F2* 5 t ha^{-1} chicken manure, E1F3 10 t ha^{-1} chicken manure, *E2F1* 300 kg ha^{-1} chemical fertilizer, *E2F2* 300 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure, *E2F3* 300 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure, *E3F1* 600 kg ha^{-1} chemical fertilizer, *E3F2* 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure, *E3F3* 600 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure

$^{a-j}$Values with different superscript letters differ significantly ($p < 0.05$)

$^{A-C}$Values with uppercase and superscript letters differ significantly ($p < 0.05$) regardless of fertilization (column) and variety (row)

However, within *Madona*, the sample obtained with 5 t ha^{-1} chicken manure (E1F2) presented a significantly higher score (7.60 ± 0.96) than that of the sample obtained with 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure (E3F2) (4.90 ± 1.79). Compared to the scores obtained with the unfertilized samples, fertilizers did not have significant effects within each carrot variety on the orange colour of the skin and longitudinal section of those carrot samples evaluated. In terms of sweetness scores, the scores of the samples obtained from *Vanessa F1* treated with 10 t ha^{-1} of chicken manure (E1F3) (7.20 ± 0.91) and the untreated one (E1F1) (7.70 ± 0.48) were significantly higher than the scores obtained from the samples from *Madona* (except for the untreated sample of this variety). In an overall rating of each sample, the *Madona* sample treated with 10 t ha^{-1} of chicken manure (E1F3) was overall (4.10 ± 2.42) significantly less appreciated than the samples obtained with the untreated *Vanessa F1* (7.70 ± 0.94) and treated with 5 t ha^{-1} of chicken manure (E1F2) (7.20 ± 0.78). The end of the evaluation of the samples was marked by a preference rating. Thus, it emerges that *Madona* treated with 600 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E3F3) was significantly less preferred (2.90 ± 1.10) than *New Kuroda* treated with 10 t ha^{-1} of chicken manure (E1F3) (5.90 ± 1.79) and the untreated variety *Vanessa F1* (E1F1) (5.00 ± 0.67).

Influence of treatments on the nutritional value of carrot samples

Data of nutrient contents according to fertilizer types and doses were mentioned (Table 4). Fertilization significantly influenced ($p < 0.05$) the values of the determined bromatological parameters with the exception of water and organic matter contents where no significant difference was observed between the different fertilizers. It is generally observed that, compared to the value obtained with the control (E1F1), chicken manure at 5 t ha^{-1} (E1F2) and 10 t ha^{-1} (E1F3) increased the ash contents of the analysed carrot samples. The effects of 600 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E3F3) and 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) were not significantly different from those recorded with the previously mentioned treatments. When comparing the protein content obtained with the control (0.69 ± 0.13 g/100 g DM), the value obtained with the chicken manure at 10 t ha^{-1} (0.82 ± 0.20 g/100 g DM) and the chemical fertilizer at 300 kg ha^{-1} (0.85 ± 0.24 g/100 g DM) and 600 kg ha^{-1} (0.81 ± 0.14 g/100 g DM) significantly increased the protein content. These treatments therefore correspond to the types of fertilizers with the highest protein content in the samples. As for the influence of fertilizers on lipid values, it appears that when comparing the value obtained with the control (0.23 ± 0.05 g/100 g DM), fertilizers significantly reduced the lipid content of carrot samples. The values of carbohydrate showed significant variations between the types of fertilizers applied. From the values obtained, the highest content (7.03 ± 0.92 g/100 g DM) was obtained with the unfertilized sample and this is compared with the values obtained with the chemical fertilizer at 300 kg ha^{-1} (6.23 ± 0.70 g/100 g DM) and 600 kg ha^{-1} (6.25 ± 1.04 g/100 g DM). In terms of reducing sugars, only the 5 t ha^{-1} chicken manure treatment (E1F2) showed the highest content (0.014 ± 0.003 g/100 g DM) compared to the value obtained with the control (0.011 ± 0.003 g/100 g DM). With regard to the carotenoid content, the chicken manure at 10 t ha^{-1} had the highest value (938.40 ± 529.92 μg/100 g DM) compared to the control, which had the lowest value (247.04 ± 195.93 μg/100 g DM). Comparing the NDF (Neutral Detergent Fibre) values obtained with the control (2.06 ± 0.43 g/100 g DM), the NDF contents were significantly reduced after cultivation with fertilizers. However, by observing the NDF contents of treatments such as 300 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure (E2F3) and 300 kg ha^{-1} chemical fertilizer (E2F1), it can be noted that these treatments obtain high NDF value in the carrot samples. With regard to ADF (Acid Detergent Fibre) content, the treatments 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) and 300 kg ha^{-1} of chemical fertilizer (E2F1) were recorded as those that obtained high ADF values. The highest ADL (Acid Detergent Lignin) content (1.10 ± 0.33 g/100 g DM) was obtained with 300 kg ha^{-1} of chemical fertilizer (E2F1) while the lowest ADL content was obtained with the control (0.45 ± 0.18 g/100 g DM). The highest cellulose contents were obtained with treatments such as 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E2F3), the control (E1F1) and 300 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure (E2F3) corresponding to 0.66 ± 0.22 g/100 g DM; 0.64 ± 0.17 g/100 g DM and 0.59 ± 0.31 g/100 g DM respectively. Comparing the hemicellulose value obtained with the control (0.58 ± 0.26 g/100 g DM) to those obtained with the fertilizers, fertilization significantly lowered these hemicellulose values in the samples. These contents vary from 0.26 ± 0.12 g/100 g DM to 0.58 ± 0.25 g/100 g DM.

Results regarding the determination of the influence of variety on the nutrient contents of carrots were stated (Table 4). Most of the nutrients in the analysed carrot samples were significantly influenced ($p < 0.05$) by the genotype of the carrots being studied. Among the carrot varieties studied, the highest ash contents were obtained with *New Kuroda* (1.08 ± 0.25) and *Madona* (1.08 ± 0.23)

Table 4 Effects of variety and fertilizer type interactions on the nutritional value of cultivated carrots

Parameters	Fertilizers										
	Varieties	**E1F1**	**E1F2**	**E1F3**	**E2F1**	**E2F2**	**E2F3**	**E3F1**	**E3F2**	**E3F3**	**Means**
Moisture (% FW)	New Kuroda	91.35 ± 1.26^{abc}	91.94 ± 0.68^{abc}	91.44 ± 2.03^{abc}	91.51 ± 0.78^{abc}	89.62 ± 3.98^{c}	90.63 ± 0.36^{bc}	92.34 ± 1.55^{abc}	92.31 ± 0.54^{abc}	92.18 ± 0.27^{abc}	91.48 ± 1.77^{A}
	Pamela +	90.61 ± 0.38^{bc}	91.15 ± 0.63^{abc}	92.04 ± 0.44^{abc}	91.42 ± 0.51^{abc}	93.63 ± 1.53^{a}	92.03 ± 0.24^{abc}	90.94 ± 1.73^{abc}	91.71 ± 1.27^{abc}	91.04 ± 0.07^{abc}	91.62 ± 1.22^{A}
	Madona	90.78 ± 0.79^{abc}	91.14 ± 0.46^{abc}	91.52 ± 0.85^{abc}	92.75 ± 0.43^{ab}	92.49 ± 1.59^{ab}	92.12 ± 0.44^{abc}	92.04 ± 0.68^{abc}	91.29 ± 0.81^{abc}	91.50 ± 1.40^{abc}	91.74 ± 1.05^{A}
	Amazonia	92.45 ± 1.13^{abc}	90.86 ± 1.00^{abc}	91.58 ± 1.67^{abc}	90.73 ± 3.02^{bc}	91.82 ± 1.17^{abc}	91.65 ± 0.80^{abc}	91.13 ± 1.54^{abc}	92.79 ± 0.56^{ab}	92.88 ± 0.52^{ab}	91.76 ± 1.54^{A}
	Vanessa F1	90.26 ± 0.61^{bc}	90.40 ± 0.45^{bc}	90.48 ± 1.24^{bc}	91.59 ± 0.56^{abc}	92.56 ± 1.40^{ab}	92.15 ± 0.53^{abc}	91.42 ± 0.11^{abc}	91.02 ± 0.43^{abc}	90.71 ± 1.86^{bc}	91.18 ± 1.17^{A}
	Means	91.09 ± 1.14^{A}	91.09 ± 0.81^{A}	91.41 ± 1.37^{A}	91.60 ± 1.50^{A}	92.02 ± 2.45^{A}	91.72 ± 0.75^{A}	91.57 ± 1.31^{A}	91.83 ± 0.98^{A}	91.66 ± 1.27^{A}	
Ash (g/100 g DM)	New Kuroda	$0.96 \pm 0.14^{defghijklm}$	$1.02 \pm 0.09^{cdefghijkl}$	1.14 ± 0.28^{abcdefgh}	$1.03 \pm 0.10^{bcdefghijkl}$	1.19 ± 0.45^{abcdef}	1.37 ± 0.04^{ab}	0.71 ± 0.07^{klm}	$1.12 \pm 0.11^{abcdefghi}$	1.20 ± 0.04^{abcde}	1.08 ± 0.25^{A}
	Pamela +	$0.97 \pm 0.09^{defghijklm}$	$0.97 \pm 0.08^{defghijklm}$	$1.05 \pm 0.07^{abcdefghij}$	0.69 ± 0.01^{lm}	0.65 ± 0.16^{m}	0.78 ± 0.05^{ijklm}	$1.05 \pm 0.16^{abcdefghijk}$	$0.91 \pm 0.14^{efghijklm}$	$1.11 \pm 0.01^{abcdefghi}$	0.91 ± 0.18^{C}
	Madona	$0.97 \pm 0.07^{defghijklm}$	1.39 ± 0.06^{a}	1.26 ± 0.14^{abcd}	0.84 ± 0.05^{ghijklm}	0.85 ± 0.18^{fghijklm}	$0.96 \pm 0.04^{defghijklm}$	$0.92 \pm 0.08^{efghijklm}$	1.35 ± 0.14^{abc}	1.19 ± 0.20^{abcdef}	1.08 ± 0.23^{A}
	Amazonia	$0.92 \pm 0.15^{efghijklm}$	1.16 ± 0.08^{abcdefg}	$0.97 \pm 0.20^{defghijklm}$	1.28 ± 0.43^{abcd}	$0.92 \pm 0.12^{efghijklm}$	$0.97 \pm 0.10^{defghijklm}$	1.15 ± 0.20^{abcdefg}	0.74 ± 0.05^{jklm}	$1.02 \pm 0.08^{cdefghijkl}$	1.01 ± 0.23^{AB}
	Vanessa F1	$0.98 \pm 0.05^{defghijklm}$	$1.07 \pm 0.04^{abcdefghij}$	$1.11 \pm 0.14^{abcdefghi}$	$0.90 \pm 0.08^{efghijklm}$	0.83 ± 0.16^{ghijklm}	0.79 ± 0.06^{hijklm}	$0.97 \pm 0.02^{defghijklm}$	$1.05 \pm 0.03^{abcdefghijk}$	$1.10 \pm 0.22^{abcdefghi}$	0.98 ± 0.15^{BC}
	Means	0.96 ± 0.10^{BC}	1.12 ± 0.16^{A}	1.11 ± 0.19^{A}	0.95 ± 0.28^{BC}	0.89 ± 0.29^{C}	0.97 ± 0.22BC	0.96 ± 0.19^{BC}	1.03 ± 0.23^{AB}	1.13 ± 0.14^{A}	
Organic matter (% DM)	New Kuroda	7.69 ± 1.12^{abcd}	7.03 ± 0.59^{abcd}	7.43 ± 1.75^{abcd}	7.45 ± 0.68^{abcd}	9.18 ± 3.54^{a}	7.99 ± 0.32^{abcd}	6.95 ± 1.48^{abcd}	6.56 ± 0.44^{bcd}	6.62 ± 0.23^{bcd}	7.44 ± 1.58^{AB}
	Pamela +	8.42 ± 0.29^{abc}	7.88 ± 0.55^{abcd}	6.90 ± 0.38^{abcd}	7.88 ± 0.52^{abcd}	5.72 ± 1.38^{d}	7.18 ± 0.19^{abcd}	8.01 ± 1.58^{abcd}	7.38 ± 1.12^{abcd}	7.85 ± 0.07^{abcd}	7.47 ± 1.09^{AB}
	Madona	8.25 ± 0.72^{abc}	7.47 ± 0.40^{abcd}	7.22 ± 0.71^{abcd}	6.41 ± 0.38^{bcd}	6.65 ± 1.41^{bcd}	6.92 ± 0.40^{abcd}	7.04 ± 0.60^{abcd}	7.35 ± 0.67^{abcd}	7.31 ± 1.20^{abcd}	7.18 ± 0.89^{B}
	Amazonia	6.63 ± 0.98^{bcd}	7.98 ± 0.92^{abcd}	7.45 ± 1.48^{abcd}	7.99 ± 2.59^{abcd}	7.27 ± 1.04^{abcd}	7.38 ± 0.71^{abcd}	7.71 ± 1.34^{abcd}	6.47 ± 0.51^{bcd}	6.09 ± 0.44^{cd}	7.22 ± 1.34^{B}
	Vanessa F1	8.75 ± 0.57^{ab}	8.53 ± 0.42^{abc}	8.42 ± 1.10^{abc}	7.51 ± 0.48^{abcd}	6.61 ± 1.24^{bcd}	7.05 ± 0.48^{abcd}	7.61 ± 0.09^{abcd}	7.93 ± 0.41^{abcd}	8.18 ± 1.64^{abcd}	7.84 ± 1.04^{A}
	Means	7.95 ± 1.05^{A}	7.78 ± 0.76^{A}	7.48 ± 1.22^{A}	7.45 ± 1.29^{A}	7.09 ± 2.16^{A}	7.31 ± 0.57^{A}	7.46 ± 1.16^{A}	7.14 ± 0.84^{A}	7.21 ± 1.17^{A}	
Proteins (g/100 g DM)	New Kuroda	$0.68 \pm 0.12^{defghijkl}$	$0.72 \pm 0.02^{cdefghijk}$	0.65 ± 0.14^{fghijkl}	0.66 ± 0.10^{efghijkl}	$0.76 \pm 0.31^{cdefghijk}$	$0.80 \pm 0.04^{bcdefghijk}$	0.71 ± 0.16^{defghijk}	0.63 ± 0.05^{hijkl}	$0.70 \pm 0.03^{defghijkl}$	0.70 ± 0.14^{C}
	Pamela +	0.62 ± 0.01^{hijkl}	0.59 ± 0.05^{jkl}	0.62 ± 0.04^{hijkl}	$0.79 \pm 0.05^{bcdefghijk}$	0.43 ± 0.10^{l}	$0.73 \pm 0.03^{cdefghijk}$	$0.86 \pm 0.11^{abcdefghi}$	0.98 ± 0.19^{abc}	0.64 ± 0.00^{fghijkl}	0.69 ± 0.18^{C}
	Madona	$0.75 \pm 0.13^{cdefghijk}$	0.65 ± 0.05^{fghijkl}	0.92 ± 0.07^{abcdef}	$0.74 \pm 0.04^{cdefghijk}$	0.55 ± 0.10^{kl}	0.67 ± 0.08^{efghijkl}	0.91 ± 0.10^{abcdefg}	$0.77 \pm 0.06^{cdefghijk}$	$0.74 \pm 0.11^{cdefghijk}$	0.74 ± 0.14^{BC}
	Amazonia	0.54 ± 0.05^{kl}	$0.86 \pm 0.09^{abcdefghi}$	0.93 ± 0.19^{abcde}	1.12 ± 0.39^{a}	0.65 ± 0.13^{efghijkl}	$0.82 \pm 0.07^{bcdefghijk}$	$0.68 \pm 0.13^{defghijkl}$	0.59 ± 0.07^{ijkl}	$0.75 \pm 0.06^{cdefghijk}$	0.77 ± 0.23^{B}
	Vanessa F1	$0.84 \pm 0.05^{bcdefghij}$	$0.78 \pm 0.09^{cdefghijk}$	0.98 ± 0.13^{abc}	0.95 ± 0.06^{abcd}	0.64 ± 0.11^{ghijkl}	$0.79 \pm 0.06^{bcdefghijk}$	0.89 ± 0.03^{abcdefgh}	$0.77 \pm 0.03^{cdefghijk}$	1.06 ± 0.19^{ab}	0.86 ± 0.15^{A}
	Means	0.69 ± 0.13^{DE}	0.72 ± 0.12^{CD}	0.82 ± 0.20^{AB}	0.85 ± 0.24^{A}	0.61 ± 0.19^{E}	0.76 ± 0.08^{ABCD}	0.81 ± 0.14^{ABC}	0.75 ± 0.17^{BCD}	0.78 ± 0.18^{ABCD}	
Lipid content (g/100 g DM)	New Kuroda	0.28 ± 0.04^{a}	0.21 ± 0.01^{abcde}	0.19 ± 0.03^{bcdefg}	0.20 ± 0.02^{abcdef}	0.17 ± 0.11^{bcdefgh}	0.19 ± 0.00^{bcdefg}	0.17 ± 0.06^{cdefgh}	0.17 ± 0.01^{cdefgh}	0.17 ± 0.01^{cdefgh}	0.19 ± 0.06^{A}
	Pamela +	0.26 ± 0.05^{ab}	0.16 ± 0.03^{cdefgh}	0.18 ± 0.01^{bcdefg}	0.18 ± 0.01^{bcdefg}	0.09 ± 0.02^{h}	0.19 ± 0.03^{bcdefg}	0.19 ± 0.05^{bcdefg}	0.16 ± 0.04^{cdefgh}	0.24 ± 0.01^{abcd}	0.18 ± 0.05^{AB}
	Madona	0.21 ± 0.01^{abcde}	0.18 ± 0.02^{bcdefg}	0.14 ± 0.04^{efgh}	0.13 ± 0.01^{efgh}	0.19 ± 0.03^{bcdefg}	0.17 ± 0.04^{bcdefgh}	0.11 ± 0.01^{gh}	0.19 ± 0.02^{bcdefg}	0.12 ± 0.01^{fgh}	0.16 ± 0.04^{C}
	Amazonia	0.16 ± 0.03^{cdefgh}	0.24 ± 0.01^{abcd}	0.21 ± 0.06^{abcdef}	0.17 ± 0.10^{bcdefgh}	0.14 ± 0.06^{efgh}	0.11 ± 0.01^{gh}	0.15 ± 0.05^{cdefgh}	0.12 ± 0.01^{fgh}	0.19 ± 0.02^{bcdefg}	0.16 ± 0.06^{BC}
	Vanessa F1	0.22 ± 0.01^{abcde}	0.18 ± 0.03^{bcdefg}	0.20 ± 0.07^{abcdef}	0.11 ± 0.00^{gh}	0.24 ± 0.04^{abc}	0.16 ± 0.01^{cdefgh}	0.15 ± 0.03^{defgh}	0.17 ± 0.01^{bcdefgh}	0.19 ± 0.05^{bcdefg}	0.18 ± 0.05^{ABC}
	Means	0.23 ± 0.05^{A}	0.19 ± 0.03^{B}	0.18 ± 0.05^{BC}	0.16 ± 0.06^{C}	0.17 ± 0.08^{BC}	0.16 ± 0.04^{BC}	0.15 ± 0.05^{C}	0.16 ± 0.03^{C}	0.18 ± 0.04^{BC}	
6.93 ± 1.40abc	New Kuroda	6.72 ± 0.97^{abc}	6.09 ± 0.58^{abc}	6.59 ± 1.58^{abc}	6.59 ± 0.56^{abc}	8.26 ± 3.12^{a}	6.99 ± 0.28^{abc}	6.07 ± 1.26^{bc}	5.76 ± 0.37^{bc}	5.75 ± 0.19^{bc}	6.54 ± 1.42^{AB}
	Pamela +	7.53 ± 0.26^{ab}	7.14 ± 0.48^{abc}	6.09 ± 0.34^{abc}	5.19 ± 1.25^{c}	6.90 ± 0.45^{abc}	6.27 ± 0.13^{abc}	6.96 ± 1.42^{abc}	6.23 ± 0.90^{abc}	6.96 ± 0.07^{abc}	6.59 ± 0.96^{AB}
	Madona	7.28 ± 0.60^{abc}	6.65 ± 0.33^{abc}	6.16 ± 0.62^{abc}	5.54 ± 0.33^{bc}	5.91 ± 1.28^{bc}	6.08 ± 0.27^{abc}	6.02 ± 0.50^{bc}	6.39 ± 0.59^{abc}	6.45 ± 1.09^{abc}	6.28 ± 0.80^{B}
	Amazonia	5.93 ± 0.90^{bc}	6.88 ± 0.83^{abc}	6.31 ± 1.22^{abc}	6.69 ± 2.10^{ab}c	6.47 ± 0.86^{abc}	6.45 ± 0.63^{abc}	6.88 ± 1.16^{abc}	5.75 ± 0.43^{bc}	5.16 ± 0.37^{c}	6.28 ± 1.12^{B}
	Vanessa F1	7.69 ± 0.53^{ab}	7.56 ± 0.30^{ab}	7.22 ± 0.90^{abc}	6.45 ± 0.42^{abc}	5.73 ± 1.09^{bc}	6.09 ± 0.41^{abc}	6.57 ± 0.08^{abc}	6.98 ± 0.37^{abc}		6.80 ± 0.92^{A}
	Means	7.03 ± 0.92^{A}	6.86 ± 0.71^{AB}	6.48 ± 1.04^{AB}	6.23 ± 0.70^{B}	6.31 ± 1.93^{AB}	6.38 ± 0.49^{AB}	6.25 ± 1.04^{B}	6.43 ± 1.06^{AB}	6.50 ± 1.03^{AB}	

Table 4 (continued)

Parameters	Fertilizers										
	Varieties	**E1F1**	**E1F2**	**E1F3**	**E2F1**	**E2F2**	**E2F3**	**E3F1**	**E3F2**	**E3F3**	**Means**
Reducing sugars (g/100 g DM)	New Kuroda	0.012 ± 0.00^{defgh}	0.016 ± 0.00^{ab}	0.015 ± 0.00^{bcd}	0.005 ± 0.00^{qrs}	0.011 ± 0.00^{efghij}	0.015 ± 0.00^{bc}	0.009 ± 0.00^{ijklmno}	0.007 ± 0.00^{nopqr}	0.007 ± 0.00^{opqr}	0.011 ± 0.002^{AB}
	Pamela +	0.011 ± 0.00^{efghij}	0.011 ± 0.00^{efghij}	0.005 ± 0.00^{qrs}	0.010 ± 0.00^{ghijk}	0.010 ± 0.00^{ghijkl}	0.011 ± 0.00^{efghij}	0.008 ± 0.00^{klmnop}	0.010 ± 0.00^{fghijk}	0.008 ± 0.00^{klmnop}	0.010 ± 0.004^{C}
	Madona	0.007 ± 0.00^{lmnopqr}	0.013 ± 0.00^{cdef}	0.013 ± 0.00^{cde}	0.008 ± 0.00^{lmnopq}	0.010 ± 0.00^{ijklmn}	0.006 ± 0.00^{pqr}	0.003 ± 0.00^{s}	0.012 ± 0.00^{efgh}i	0.011 ± 0.00^{efghij}	0.009 ± 0.004^{C}
	Amazonia	0.016 ± 0.00^{bc}	0.012 ± 0.00^{defg}	0.009 ± 0.00^{jklmno}	0.007 ± 0.00^{opqr}	0.011 ± 0.00^{efghijk}	0.016 ± 0.00^{abc}	0.009 ± 0.00^{jklmno}	0.010 ± 0.00^{hijklm}	0.008 ± 0.00^{klmnop}	0.010 ± 0.003^{B}
	Vanessa F1	0.007 ± 0.00^{mnopqr}	0.018 ± 0.00^{a}	0.009 ± 0.00^{jklmno}	0.009 ± 0.00^{jklmno}	0.009 ± 0.00^{jklmno}	0.016 ± 0.00^{bc}	0.005 ± 0.00^{rs}	0.009 ± 0.00^{jklmno}	0.010 ± 0.00^{ghijkl}	0.011 ± 0.004^{A}
	Means	0.011 ± 0.003^{C}	0.014 ± 0.003^{A}	0.010 ± 0.003^{CD}	0.008 ± 0.002^{F}	0.010 ± 0.001^{CD}	0.013 ± 0.004^{B}	0.007 ± 0.003^{G}	0.010 ± 0.002^{DE}	0.009 ± 0.002^{E}	
Total Carotenoids (µg/100 g DM)	New Kuroda	463.60 ± 3.59^{nop}	742.67 ± 10.77^{hij}	1044.24 ± 17.45^{d}	526.62 ± 14.12^{lm}	962.57 ± 5.17^{e}	713.09 ± 14.47^{ij}	558.13 ± 12.94^{kl}	592.85 ± 6.05^{k}	1226.85 ± 5.97^{b}	758.96 ± 250.48^{B}
	Pamela +	78.59 ± 13.46^{xyz}	155.60 ± 21.29^{vwx}	151.10 ± 9.81^{vwx}	405.73 ± 7.18^{p}	189.04 ± 10.49^{tuv}	469.39 ± 6.05^{mno}	186.47 ± 13.94^{uvw}	248.84 ± 10.77^{rs}	77.16 ± 13.69^{yz}	220.12 ± 128.54^{E}
	Madona	495.75 ± 13.02^{mn}	1146.47 ± 15.46^{c}	855.19 ± 38.36^{f}	725.95 ± 8.15^{ij}	1143.90 ± 35.40^{c}	447.53 ± 39.45nop	746.53 ± 16.39^{hij}	700.87 ± 19.00^{j}	1201.13 ± 32.47^{bc}	829.26 ± 270.41A
	Amazonia	128.601 ± 15.65^{wxy}	527.90 ± 23.48^{lm}	1781.76 ± 15.56^{a}	164.61 ± 2.63^{uvw}	855.19 ± 32.56^{f}	800.54 ± 42.15^{fgh}	948.43 ± 24.78^{e}	220.55 ± 3.59^{stu}	718.23 ± 6.05^{ij}	682.87 ± 492.23^{C}
	Vanessa F1	49.511 ± 5.27^{z}	286.137 ± 21.43^{qr}	859.69 ± 9.81^{f}	425.02 ± 13.06^{op}	527.26 ± 3.59^{lm}	331.14 ± 17.02^{q}	769.03 ± 2.63^{ghi}	246.27 ± 26.80^{rst}	808.89 ± 20.58^{fg}	478.11 ± 269.72^{D}
	Means	247.04 ± 195.93^{H}	571.76 ± 357.49^{E}	938.40 ± 529.92^{A}	449.58 ± 185.58^{F}	735.59 ± 345.43^{C}	552.34 ± 180.49^{E}	641.72 ± 268.17^{D}	401.88 ± 207.16^{G}	806.46 ± 425.14^{B}	
NDF (g/100 g DM)	New Kuroda	$1.78 \pm 0.28^{efghijklmnopq}$	1.29 ± 0.08^{opqrs}	$1.48 \pm 0.37^{klmnopqrs}$	1.41 ± 0.18^{lmnopqrs}	$1.85 \pm 0.68^{efghijklmnop}$	$1.92 \pm 0.03^{efghijklmn}$	$1.61 \pm 0.29^{hijklmnopqrs}$	$1.65 \pm 0.14^{ghijklmnopqrs}$	2.32 ± 0.07^{bcdef}	1.70 ± 0.40^{C}
	Pamela +	2.13 ± 0.04^{cdefghi}	1.39 ± 0.07^{mnopqrs}	1.14 ± 0.06^{s}	2.78 ± 0.22^{ab}	1.19 ± 0.29^{rs}	2.22 ± 0.07^{bcdefg}	$1.56 \pm 0.27^{ijklmnopqrs}$	1.44 ± 0.16^{lmnopqrs}	$1.77 \pm 0.07^{fghijklmnopqr}$	1.74 ± 0.54^{BC}
	Madona	2.20 ± 0.18^{bcdefg}	2.08 ± 0.07^{cdefghij}	1.39 ± 0.17^{mnopqrs}	2.19 ± 0.13^{cdefgh}	1.27 ± 0.30^{pqrs}	$1.86 \pm 0.07^{efghijklmno}$	$1.84 \pm 0.17^{efghijklmnop}$	2.35 ± 0.22^{bcde}	1.38 ± 0.24^{nopqrs}	1.84 ± 0.43^{B}
	Amazonia	2.61 ± 0.42^{bc}	$1.52 \pm 0.12^{jklmnopqrs}$	1.46 ± 0.26^{lmnopqrs}	2.54 ± 0.81^{bcd}	$1.61 \pm 0.21^{ijklmnopqrs}$	3.20 ± 0.31^{a}	$1.94 \pm 0.29^{efghijklm}$	1.34 ± 0.10^{opqrs}	2.24 ± 0.16^{bcdef}	2.05 ± 0.70^{A}
	Vanessa F1	$1.58 \pm 0.09^{ijklmnopqrs}$	$1.61 \pm 0.10^{ijklmnopqrs}$	$1.59 \pm 0.26^{ijklmnopqrs}$	$1.98 \pm 0.13^{defghijkl}$	1.26 ± 0.24^{qrs}	$1.82 \pm 0.12^{efghijklmnopq}$	$1.61 \pm 0.05^{ijklmnopqrs}$	$2.04 \pm 0.14^{cdefghijk}$	$1.55 \pm 0.27^{jklmnopqrs}$	1.67 ± 0.28^{C}
	Means	2.06 ± 0.43^{A}	1.58 ± 0.29^{CD}	1.41 ± 0.28^{D}	2.18 ± 0.60^{A}	1.43 ± 0.44^{D}	2.20 ± 0.55^{A}	1.71 ± 0.27^{BC}	1.76 ± 0.42^{BC}	1.84 ± 0.42^{B}	
ADF (g/100 g DM)	New Kuroda	$1.40 \pm 0.21^{efghijklm}$	0.90 ± 0.03^{nop}	$1.18 \pm 0.29^{hijklmnop}$	1.03 ± 0.10^{lmnop}	$1.44 \pm 0.47^{defghijkl}$	1.58 ± 0.06^{cdefghi}	$1.18 \pm 0.22^{hijklmnop}$	$1.51 \pm 0.15^{cdefghijk}$	$1.46 \pm 0.05^{defghijkl}$	1.30 ± 0.30^{C}
	Pamela +	1.16 ± 0.09^{ijklmnop}	1.17 ± 0.09^{ijklmnop}	0.85 ± 0.04^{op}	2.06 ± 0.21^{ab}	0.89 ± 0.22^{nop}	1.56 ± 0.11^{cdefghij}	$1.39 \pm 0.25^{efghijklm}$	1.07 ± 0.09^{lmnop}	1.57 ± 0.04^{cdefghi}	1.31 ± 0.39^{C}
	Madona	1.67 ± 0.14^{bcdefg}	1.63 ± 005^{bcdefg}	0.98 ± 0.11^{mnop}	$1.42 \pm 0.07^{efghijklm}$	0.82 ± 0.18^{p}	1.63 ± 0.08^{cdefg}	1.55 ± 0.17^{cdefghij}	1.90 ± 0.15^{abc}	1.13 ± 0.16^{jklmnop}	1.41 ± 0.36^{B}
	Amazonia	1.85 ± 0.35^{abcd}	1.10 ± 0.11^{klmnop}	1.34 ± 0.24^{fghijklm}	1.79 ± 0.51^{abcde}	1.03 ± 0.16^{lmnop}	2.18 ± 0.21^{a}	1.71 ± 0.26^{bcdef}	1.07 ± 0.06^{lmnop}	1.61 ± 0.11^{cdefgh}	1.52 ± 0.45^{A}
	Vanessa F1	$1.32 \pm 0.07^{fghijklmn}$	1.35 ± 0.13^{fghijklm}	$1.41 \pm 0.19^{efghijklm}$	1.71 ± 0.11^{bcdef}	1.03 ± 0.18^{lmnop}	$1.27 \pm 0.09^{ghijklmno}$	$1.30 \pm 0.04^{fghijklmn}$	$1.42 \pm 0.13^{defghijkl}$	1.09 ± 0.15^{klmnop}	1.32 ± 0.22^{BC}
	Means	1.48 ± 0.31^{BC}	1.23 ± 0.26^{DE}	1.15 ± 0.28^{EF}	1.60 ± 0.43^{AB}	1.04 ± 0.33^{F}	1.64 ± 0.32^{A}	1.43 ± 0.27^{C}	1.39 ± 0.33^{C}	1.37 ± 0.25^{CD}	

Table 4 (continued)

Parameters	Fertilizers										
	Varieties	**E1F1**	**E1F2**	**E1F3**	**E2F1**	**E2F2**	**E2F3**	**E3F1**	**E3F2**	**E3F3**	**Means**
ADL (g/100 g DM)	New Kuroda	0.83 ± 0.16^{hijkl}	0.79 ± 0.02^{hijkl}	0.97 ± 0.27^{defghij}	0.69 ± 0.02^{jklmn}	0.37 ± 0.14^{op}	0.99 ± 0.02^{defghij}	1.08 ± 0.18^{cdefghi}	1.17 ± 0.15^{cdef}	0.98 ± 0.03^{defghij}	0.87 ± 0.26^{BC}
	Pamela +	0.43 ± 0.03^{nop}	0.85 ± 0.11^{hijkl}	0.55 ± 0.03^{lmnop}	1.48 ± 0.22^{ab}	0.34 ± 0.09^{p}	0.66 ± 0.08^{klmno}	1.16 ± 0.19^{cdefg}	0.78 ± 0.07^{ijkl}	1.19 ± 0.04^{bcde}	0.83 ± 0.38^{CD}
	Madona	1.09 ± 0.07^{cdefgh}	0.73 ± 0.07^{jklm}	0.79 ± 0.07^{hijkl}	0.98 ± 0.06^{defghij}	0.27 ± 0.04^{p}	0.81 ± 0.07^{hijkl}	1.21 ± 0.14^{bcd}	1.53 ± 0.09^{a}	0.97 ± 0.19^{defghij}	0.93 ± 0.34^{AB}
	Amazonia	0.98 ± 0.20^{defghij}	0.44 ± 0.03^{mnop}	1.15 ± 0.23^{cdefg}	1.19 ± 0.41^{bcde}	0.70 ± 0.05^{jklmn}	1.49 ± 0.14^{ab}	1.31 ± 0.18^{abc}	0.90 ± 0.02^{efghijk}	0.79 ± 0.06^{hijkl}	0.99 ± 0.35^{A}
	Vanessa F1	0.87 ± 0.05^{ghijk}	0.45 ± 0.02^{mnop}	0.98 ± 0.16^{defghij}	1.15 ± 0.08^{cdefg}	0.55 ± 0.08^{lmnop}	0.99 ± 0.07^{defghij}	0.88 ± 0.01^{fghijk}	0.56 ± 0.06^{lmnop}	0.70 ± 0.10^{jklmn}	0.79 ± 0.24^{D}
	Means	0.45 ± 0.18^{E}	0.65 ± 0.18^{D}	0.89 ± 0.26^{BC}	1.10 ± 0.33^{A}	0.84 ± 0.26^{C}	0.98 ± 0.30^{B}	1.13 ± 0.20^{A}	0.98 ± 0.35^{B}	0.93 ± 0.20^{BC}	
Cellulose (g/100 g DM)	New Kuroda	0.56 ± 0.09^{efghij}	0.11 ± 0.02^{s}	0.21 ± 0.03^{opqrs}	0.34 ± 0.09^{klmnopqr}	1.07 ± 0.33^{a}	0.59 ± 0.05^{efgh}	0.11 ± 0.03^{s}	0.33 ± 0.01^{klmnopqr}	0.47 ± 0.02^{ghijkl}	0.42 ± 0.31^{C}
	Pamela +	0.74 ± 0.06^{bcde}	0.32 ± 0.03^{klmnopqr}	$0.29 \pm 0.02^{klmnopqrs}$	0.57 ± 0.01^{efghi}	0.56 ± 0.14^{efghij}	0.90 ± 0.03^{ab}	0.23 ± 0.06^{nopqrs}	0.28 ± 0.02^{lmnopqrs}	0.39 ± 0.00^{ijklmnop}	0.48 ± 0.23^{B}
	Madona	0.57 ± 0.08^{efghi}	0.90 ± 0.02^{ab}	0.18 ± 0.06^{qrs}	0.43 ± 0.04^{hijklmn}	0.54 ± 0.15^{fghij}	0.82 ± 0.01^{bcd}	0.34 ± 0.03^{klmnopqr}	0.37 ± 0.06^{jklmnopq}	0.16 ± 0.04^{rs}	0.48 ± 0.25^{B}
	Amazonia	0.87 ± 0.14^{bc}	0.66 ± 0.11^{defg}	0.19 ± 0.01^{pqrs}	0.59 ± 0.10^{efgh}	0.33 ± 0.11^{klmnopqr}	0.69 ± 0.07^{cdef}	0.40 ± 0.08^{hijklmno}	0.17 ± 0.04^{rs}	0.82 ± 0.06^{bcd}	0.53 ± 0.26^{A}
	Vanessa F1	0.45 ± 0.03^{hijklm}	0.90 ± 0.15^{ab}	0.43 ± 0.04^{hijklm}	0.56 ± 0.04^{efghij}	0.48 ± 0.14^{ghijk}	0.28 ± 0.02^{mnopqrs}	0.42 ± 0.05^{hijklmn}	0.87 ± 0.07^{bc}	0.40 ± 0.05^{ijklmno}	0.53 ± 0.22^{A}
	Means	0.64 ± 0.17^{AB}	0.58 ± 0.33^{B}	0.26 ± 0.10^{E}	0.50 ± 0.12^{C}	0.59 ± 0.31^{AB}	0.66 ± 0.22^{A}	0.30 ± 0.13^{E}	0.41 ± 0.25^{D}	0.45 ± 0.22^{CD}	
Hemicellulose (g/100 g DM)	New Kuroda	0.38 ± 0.06^{jklmnopq}	0.39 ± 0.06^{ijklmnop}	$0.30 \pm 0.08^{klmnopqrst}$	0.38 ± 0.08^{jklmnopq}	0.41 ± 0.21^{ijklmno}	$0.33 \pm 0.09^{klmnopqrs}$	0.43 ± 0.07^{ijkl}	0.14 ± 0.01^{tu}	0.86 ± 0.03^{ab}	0.40 ± 0.20B
	Pamela +	0.96 ± 0.06^{a}	0.23 ± 0.04^{opqrstu}	$0.28 \pm 0.03^{klmnopqrstu}$	0.72 ± 0.01^{bcde}	$0.29 \pm 0.07^{klmnopqrst}$	0.66 ± 0.05^{cdef}	0.17 ± 0.02^{stu}	$0.37 \pm 0.08^{jklmnopqr}$	0.19 ± 0.02^{rstu}	0.43 ± 0.27^{B}
	Madona	0.54 ± 0.04^{fghij}	0.45 ± 0.02^{ghijk}	0.41 ± 0.07^{ijklmn}	0.78 ± 0.06^{bc}	0.45 ± 0.12^{hijk}	0.23 ± 0.01^{nopqrstu}	$0.29 \pm 0.03^{klmnopqrstu}$	0.44 ± 0.07^{hijk}	0.21 ± 0.08^{qrstu}	0.42 ± 0.18^{B}
	Amazonia	0.76 ± 0.08^{bc}	0.42 ± 0.03^{ijklm}	0.12 ± 0.02^{u}	0.74 ± 0.30^{bcd}	0.57 ± 0.05^{defghi}	1.03 ± 0.10^{a}	0.23 ± 0.03^{nopqrstu}	$0.25 \pm 0.04^{mnopqrstu}$	0.63 ± 0.06^{cdefg}	0.53 ± 0.30^{A}
	Vanessa F1	$0.26 \pm 0.02^{lmnopqrstu}$	$0.25 \pm 0.03^{lmnopqrstu}$	0.18 ± 0.06^{stu}	$0.27 \pm 0.02^{klmnopqrstu}$	0.22 ± 0.06^{pqrstu}	0.55 ± 0.04^{efghij}	$0.31 \pm 0.01^{klmnopqrst}$	0.62 ± 0.02^{cdefgh}	0.45 ± 0.12^{ghijk}	0.35 ± 0.15^{C}
	Means	0.58 ± 0.26^{A}	0.35 ± 0.10^{C}	0.26 ± 0.12^{D}	0.58 ± 0.25^{A}	0.39 ± 0.16^{C}	0.56 ± 0.29^{A}	0.28 ± 0.10^{D}	0.36 ± 0.17^{C}	0.47 ± 0.27^{B}	

DM dry matter, *FW* fresh weight, *NDF* neutral detergent fibre, *ADF* acid detergent fibre, *ADL* acid detergent lignin, *E1F1* control, *E1F2* 5 t ha^{-1} chicken manure, *E1F3* 10 t ha^{-1} chicken manure, *E2F1* 300 kg ha^{-1} chemical fertilizer, *E2F2* 300 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure, *E2F3* 300 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure, *E3F1* 600 kg ha^{-1} chemical fertilizer, *E3F2* 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure, *E3F3* 600 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure

$^{a-u}$Values with different superscript letters differ significantly ($p < 0.05$)

$^{A-H}$Values with uppercase and superscript letters differ significantly ($p < 0.05$) regardless of fertilization (column) and variety (row) which were significantly higher than those of the varieties *Pamela*+(0.91 ± 0.18) and *Vanessa F1* (0.98 ± 0.15). *Vanessa F1*, *New Kuroda* and *Pamela*+were recorded as having the highest value of organic matter (7.84 ± 1.04; 7.44 ± 1.58 and 7.47 ± 1.09 respectively) compared to *Madona* (7.18 ± 0.89) and *Amazonia* (7.22 ± 1.34). The highest protein content (0.86 ± 0.15 g/100 g DM) was obtained with *Vanessa F1*. The lipid content obtained with *New Kuroda* (0.19 ± 0.06 g/100 g DM) was significantly higher than those obtained with *Madona* (0.16 ± 0.04 g/100 g DM) and *Amazonia* (0.16 ± 0.06 g/100 g DM). In terms of carbohydrate content, *Vanessa F1*, *New Kuroda* and *Pamela*+had the highest values (6.80 ± 0.92 g/100 g DM; 6.54 ± 1.42 g/100 g DM and 6.59 ± 0.96 g/100 g DM respectively) compared to those obtained with *Madona* (6.28 ± 0.86 g/100 g DM) and *Amazonia* (6.28 ± 1.12 g/100 g DM). The same order was observed for reducing sugar contents where *Vanessa F1* and *New Kuroda* presented the highest contents (0.011 ± 0.004 g/100 g DM and 0.011 ± 0.002 g/100 g DM respectively). Regarding the aspect of carotenoids contents, *Madona* and *New Kuroda* presented the highest carotenoids values (829.26 ± 270.41 μg/100 g DM and 758.96 ± 250.48 μg/100 g DM respectively), while the lowest carotenoid content was obtained with *Pamela*+(220.12 ± 128.54 μg/100 g DM). Regarding NDF and ADF contents, the highest (2.05 ± 0.70 g/100 g DM and 1.52 ± 0.45 g/100 g DM respectively) were obtained with the variety *Amazonia*. Concerning ADL contents, the varieties *Amazonia* and *Madona* had higher values (0.99 ± 0.35 g/100 g DM and 0.93 ± 0.34 g/100 g DM respectively) than the other varieties. The highest cellulose values were obtained with *Vanessa F1* and *Amazonia* (0.53 ± 0.22 g/100 g DM and 0.53 ± 0.26 g/100 g DM respectively) while only *Amazonia* had the highest content (0.53 ± 0.30 g/100 g DM) of hemicellulose.

The response of the interaction between variety and fertilizer rates on the determined bromatological parameters is presented in Table 4. It can be seen that these interactions significantly ($p < 0.05$) affected the nutrient values determined. The value of moisture obtained with *Pamela*+treated with 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (93.63 ± 1.53) was significantly higher than that obtained with *New Kuroda* treated with the same fertilizer (89.62 ± 3.98). Regarding ash content, the value obtained with *Madona* treated with 5 t ha^{-1} of chicken manure (1.39 ± 0.06 g/100 g DM) was significantly higher than that obtained with *Pamela*+treated with the same fertilizer (0.97 ± 0.08 g/100 g DM). Within *New Kuroda*, the organic matter value obtained with 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E2F2) (9.18 ± 3.54 g/100 g DM) was significantly higher than those obtained with 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) and 10 t ha^{-1} of chicken manure + 600 kg ha^{-1} of chemical fertilizer (E3F3). For *Pamela*+, the value (5.72 ± 1.38 g/100 g DM) obtained with 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E2F2) was significantly low compared to those obtained with the other treatments. Within *Madona*, *Amazonia* and *Vanessa F1*, no significant interaction differences were observed. There was significant variation in proteins content within each carrot variety with the exception of the *New Kuroda* variety where there was no significant difference in values obtained with different types of fertilizer. Two treatments were significantly different within *Pamela*+in which the value of proteins obtained with 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E3F2) (0.98 ± 0.19 g/100 g DM) was significantly high compared to that obtained with 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E2F2). The values obtained in *Amazonia* showed a significant increase in proteins content compared to the control. The highest protein content (1.12 ± 0.39 g/100 g DM) was obtained with the *Amazonia* variety treated with 300 kg ha^{-1} of chemical fertilizer (E2F1).

In terms of lipid contents, within most of the carrot varieties studied, when comparing the value obtained with the control and the values obtained with the fertilized samples, the fertilization did not significantly increase the lipid contents of the carrot samples. However, the highest lipid content (0.28 ± 0.04 g/100 g DM) was obtained with the untreated *New Kuroda* variety. Concerning carbohydrates, within *New Kuroda*, the value obtained with 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E2F2) (8.26 ± 3.12 g/100 g DM) was found to be significantly higher than those obtained with 600 kg ha^{-1} of chemical fertilizer (E3F1) (6.07 ± 1.26 g/100 g DM), 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) (5.76 ± 0.37 g/100 g DM) and 600 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E3F3) (5.75 ± 0.19 g/100 g DM). For the variety *Pamela*+, the value obtained with the control was significantly higher than that obtained with 300 kg ha^{-1} of chemical fertilizer (E2F1). Within the varieties *Madona*, *Amazonia* and *Vanessa F1* no significant difference of interactions was observed.

Comparing the value of reducing sugars obtained with the control and those obtained with the fertilizers in *New Kuroda* and *Vanessa F1*, the treatments 5 t ha^{-1} of chicken manure (E1F2) and 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E2F3) gave the highest levels (0.016 g/100 g DM and 0.015 g/100 g DM respectively for *New Kuroda*; 0.018 g/100 g DM and 0.016 g/100 g DM respectively for *Vanessa F1*). It was found that, depending on the type of fertilizer in *New Kuroda*, the carotenoid values varied from 463.60 ± 3.59 µg/100 g DM to 1226.85 ± 5.97 µg/100 g DM where an increase in carotenoids content in the samples could also be observed. Within the variety *Pamela+*, a variation of 77.16 ± 13.69 µg/100 g DM to 469.39 ± 6.05 µg/100 g DM is observed. This fluctuation ranges from 447.53 ± 39.45 µg/100 g DM to 1201.13 ± 32.47 µg/100 g DM within the variety *Madona*. Within *Amazonia*, a fluctuation of 128.601 ± 15.65 µg/100 g DM to 1781.76 ± 15.56 µg/100 g DM was recorded. For *Vanessa F1*, the values range from 49.511 ± 5.27 µg/100 g DM to 859.69 ± 9.81 µg/100 g DM. When comparing the levels obtained with the controls and fertilizers, the fluctuations showed a significant increase in carotenoid levels due to fertilization. In general, the treatment that gave the highest carotenoid content was the *Amazonia* variety treated with 10 t ha^{-1} of chicken manure.

The interaction between variety and fertilizer on NDF (Neutral Detergent Fibre) content revealed that there were significant interactions between treatments. When observing the effects of fertilizers on *New Kuroda*, compared to the value obtained with the control (E1F1) (1.78 ± 0.28 g/100 g DM), the highest NDF value (2.32 ± 0.07 g/100 g DM) was obtained with 600 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E3F3). Comparing the value obtained with the control (E1F1) (2.13 ± 0.04 g/100 g DM) to those obtained with the fertilizers in *Pamela+*, only the treatment 300 kg ha^{-1} of chemical fertilizer (E2F1) was recorded as significantly ($p < 0.05$) increasing the NDF content. Within *Amazonia*, only the treatment 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure showed a higher NDF value (3.20 ± 0.31 g/100 g DM) than that obtained with the control (2.61 ± 0.42 g/100 g DM). Within *Vanessa F1* no significant variation in fertilizer effects was observed. When observing the non-significant interactions within the *New Kuroda* variety, it can be mentioned that the ADF contents varied from 1.03 ± 0.10 g/100 g DM to 1.58 ± 0.06 g/100 g DM. Within the *Pamela+* variety, the 300 kg ha^{-1} of chemical fertilizer treatment (E2F1) showed a high ADF content (2.06 ± 0.21 g/100 g DM) compared to that obtained with the control (E1F1) (1.16 ± 0.09 g/100 g DM). Although significant variations in ADF content were not observed within the varieties *Madona*, *Amazonia* and *Vanessa F1*, a fluctuation in ADF values ranging from 0.82 ± 0.18 g/100 g DM to 1.90 ± 0.15 g/100 g DM; 1.03 ± 0.16 g/100 g DM to 2.18 ± 0.21 g/100 g DM and 1.03 ± 0.18 g/100 g DM to 1.71 ± 0.11 g/100 g DM respectively. A significant increase in ADL content can be observed in the *New Kuroda* variety. ADL value obtained when this variety was treated with 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) (1.71 ± 0.11 g/100 g DM) was higher than that obtained with the control (0.83 ± 0.16 g/100 g DM). Within the *Pamela+* variety, when comparing the value obtained with the control to those obtained with the fertilizers, there was a significant increase in the ADL contents by these fertilizers. Thus, a significant variation of the ADL contents was noted ranging from 0.34 ± 0.09 g/100 g DM to 1.48 ± 0.22 g/100 g DM. Only the treatment 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) significantly increased the ADL content in the *Madona* variety. However, the treatment resulted in the highest ADL value (1.53 ± 0.09 g/100 g DM) compared to the control and other treatments. In the *Amazonia* variety, the treatments 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E2F3) and 600 kg ha^{-1} of chemical fertilizer (E3F1) allowed an increase in ADL compared to the value obtained with the control (E1F1). It was also recorded that these treatments presented the highest ADL contents (1.49 ± 0.14 g/100 g DM and 1.31 ± 0.18 g/100 g DM respectively) within this variety. For the variety *Vanessa F1*, the variation in ADL ranged from 0.45 ± 0.02 g/100 g DM to 1.15 ± 0.08 g/100 g DM. The highest cellulose content (1.07 ± 0.33 g/100 g DM) in the *New Kuroda* variety was obtained with the treatment 300 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E2F2). However, the treatments 5 t ha^{-1} of chicken manure (E1F2) and 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) significantly increased the cellulose contents in the variety *Vanessa F1* corresponding to the values of 0.90 ± 0.06 g/100 g DM and 0.87 ± 0.07 g/100 g DM respectively.

Concerning the hemicellulose contents in the *Pamela+* variety, when comparing the value obtained with the unfertilized sample and those obtained with the fertilized samples, there was no increase in the hemicellulose content in that the value obtained with the control had the highest level (0.96 ± 0.06 g/100 g DM). On the other hand, in the *Madona* variety, the 300 kg ha^{-1} chemical fertilizer treatment (E2F1) was recorded as having the highest hemicellulose content (0.78 ± 0.06 g/100 g DM). Within the *Amazonia* variety, only the sample treated with 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E2F3) showed a higher value (1.03 ± 0.10 g/100 g DM) than that obtained with the control (0.76 ± 0.08 g/100 g DM). For the variety *Vanessa F1*, compared to the value obtained with the unfertilized sample (0.26 ± 0.02 g/100 g DM), three treatments [300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E2F3), 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure (E3F2) and

600 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure (E3F3)] were recorded as increasing the hemicellulose content of the carrot samples analysed. These treatments were corresponding to 0.55 ± 0.04 g/100 g DM; 0.62 ± 0.02 g/100 g DM and 0.45 ± 0.12 g/100 g DM respectively.

Principal component analysis of the determined nutrient parameters

Figure 1 shows the distribution of observations and variables obtained after varimax rotation in the form of a biplot. In this graphical representation, the different relationships between the different nutrients variables determined in this study are presented by evaluating their links. The selection of the axes that allowed the interpretation of the data set obtained was made according to the relative criterion of interpretation. Therefore, axes D1 and D2 were retained for the interpretation of the results obtained, as these axes alone account for 51.02% of the cumulative variability and therefore concentrate the majority of the information in the actual scatterplot. In fact, the acute angles formed between the variables proteins and ash, organic matter and carbohydrates, ash and organic matter, showed that these variables are correlated with each other. The same is true for the variables NDF and ADF, cellulose and ADF, hemicellulose and ADL, ADL and NDF. Furthermore, the right angle formed between cellulose and lipids shows that these two variables are not related to each other. The obtuse angle formed between the water content and the determined macronutrients, expresses a negative relationship between these variables. Regarding the contribution of the variables to the formation of the D1 and D2 axes, it can be noted that, due to the cosine squared values (Table 5) of the angles formed between these variables and the axes, variables such as organic matter, carbohydrates, lipids, ash, proteins, and moisture content contribute strongly to the formation of the D1 axis while variables such as NDF, ADF, ADL, cellulose and hemicellulose contribute to the formation of the D2 axis. Therefore, the D1 axis could be considered as the macronutrient axis and the D2 axis as the dietary fibre axis. It can also be noted that carotenoids and reducing sugars contribute little to the formation of the D1 and D2 axes respectively. Finally, these two axes contain only 51.02% of the initial information.

From the analysis of the distribution of the variables and observations on the whole graph, we can say that

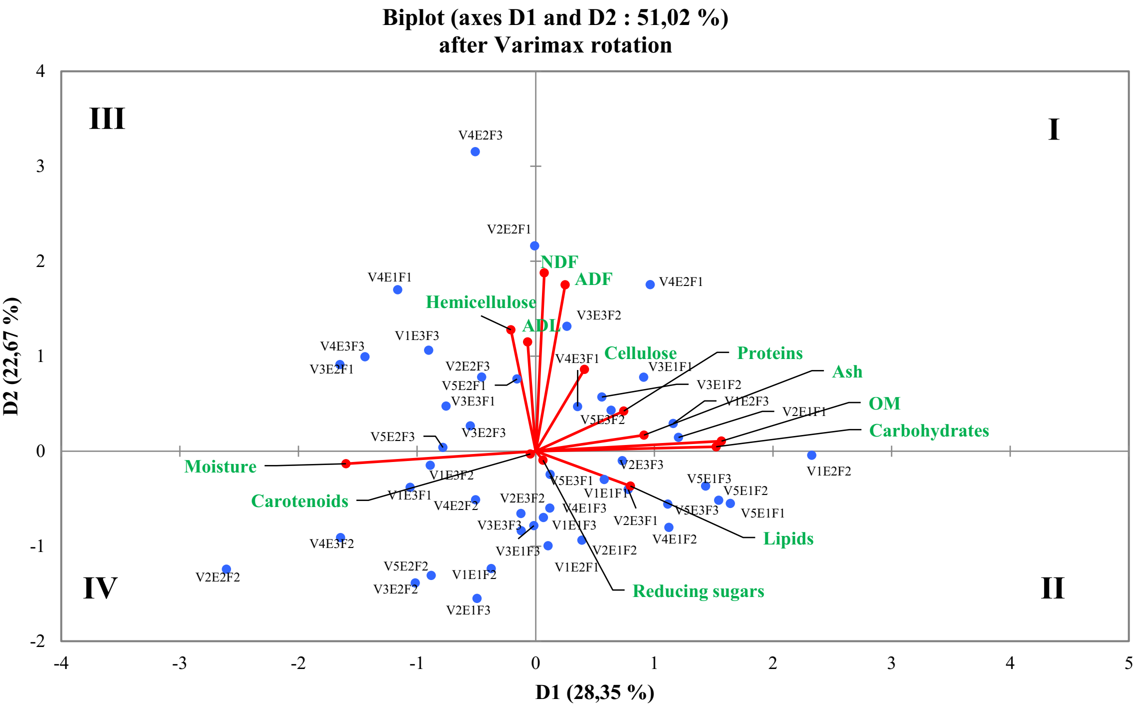

Fig. 1 Scatterplot obtained after varimax rotation representing the distribution of core samples (observations) having received different fertilizers according to the thirteen quantitative parameters related to the nutritive value of these samples. *NDF* neutral detergent fibre, *ADF* acid detergent fibre, *ADL* acid detergent lignin, V1 = *New Kuroda*, V2 = *Pamela+*, V3 = *Madona*, V4 = *Amazonia*, V5 = *Vanessa F1*, *E1F1* control, *E1F2* 5 t ha^{-1} chicken manure, *E1F3* 10 t ha^{-1} chicken manure, *E2F1* 300 kg ha^{-1} chemical fertilizer, *E2F2* 300 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure, *E2F3* 300 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure, *E3F1* 600 kg ha^{-1} chemical fertilizer, *E3F2* 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure, *E3F3* 600 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} chicken manure

Table 5 Squared cosines of variables after rotation varimax

Variables	Square cosine values	
	Axis D1	Axis D2
Moisture	0.979	0.005
Ash	0.319	0.008
Organic matter	0.938	0.003
Proteins	0.211	0.049
Lipids	0.244	0.037
Carbohydrates	0.885	0.001
Carotenoids	0.001	0.000
Reducing sugars	0.001	0.002
NDF	0.002	0.973
ADF	0.024	0.847
ADL	0.002	0.365
Cellulose	0.064	0.205
Hemicellulose	0.017	0.451

NDF neutral detergent fibre, *ADF* acid detergent fibre, *ADL* acid detergent lignin

the observations are correlated to the variables in the same quadrant. Thus, the observations in quadrant I on the positive side of the two axes have the highest values for the nutrient parameters determined, such as ash, carbohydrates, protein, organic matter, cellulose, NDF and ADF. Observations in quadrant II, which is positive on the D1 axis and negative on the D2 axis, contain the highest values for lipids and reducing sugars. Observations in quadrant III (positive on the D2 axis and negative on the D1 axis) contain the highest values for parameters such as hemicellulose and ADL. Quadrant IV contains the observations located on the negative sides of the D1 and D2 axes. The observations in this quadrant showed low magnitudes for the determined parameters. However, these observations showed high values for moisture content and carotenoids.

Quadrant I is considered the positive side of the two axes D1 and D2 and consists of the observations with the highest values for the variables determined. However, given that these two axes represent only 51.02% of the total information, some observations could be better represented in other dimensions of the analysis. Thus, only observations that are well represented (by their positive coordinates) on the D1 and D2 axes were considered. Therefore, the observations with the highest values for the determined nutrient parameters are among others V1E2F3, V2E1F1, V3E1F2, V3E3F2, V3E1F1, V4E2F1, V4E3F1 and V5E3F2. Broadly the combinations such as the carrot variety *New Kuroda* grown with 300 kg ha^{-1} of chemical fertilizer + 10 t ha^{-1} of chicken manure, the variety *Pamela* + unfertilized, the variety *Madona* fertilized with 10 t ha^{-1} of chicken manure, 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure or unfertilized, the variety *Amazonia* fertilized with 300 and 600 kg ha^{-1} of chemical fertilizer and the variety *Vanessa F1* fertilized with a combination of 600 kg ha^{-1} of chemical fertilizer + 5 t ha^{-1} of chicken manure resulted in carrots with good nutritional values.

Correlation between nutritional and sensory variables

Table 6 presents the correlation matrix between some nutrient variables and some sensory attributes. It can be seen from this table that some nutrients are significantly ($p < 0.05$) correlated with some sensory descriptors. Among these correlations, total carbohydrate was significantly associated with both sweetness and crispness. Significant correlations were found between total carotenoid and both the colour of the skin and the longitudinal section of the carrot samples. Hardness of carrots was significantly associated with both NDF and ADF. Sweetness and crispness were significant correlated, as well as crispness and crunchiness.

Discussion

Sensory analysis is an important tool for consumers in choosing their food. According to the panellists in this study, sensory attributes such as mild odour, sweetness and preference of carrot samples were significantly influenced by the type of fertilizer. However, for these three sensory attributes, the fact that the unfertilized carrot samples presented significantly higher scores than the scores of the carrot samples treated with the chemical fertilizer formulation 20-10-10 at the doses of 300 kg ha^{-1} (E2F1) and 600 kg ha^{-1} (E3F1) could be related to a negative correlation between the quality of the nutrients provided by this type of fertilizer and their involvement in the synthesis of the compounds that are responsible for the good flavour of the carrots, which consequently stimulate the consumer's preference. The chemical formulation used (NPK 20-10-10) was twice rich in nitrogen as compared potassium. It has been proven that nitrogen is involved in vegetative development while potassium is mainly involved in the synthesis of flavour compounds in the carrot plant. However, the scores obtained with the chicken manure doses were similar to those obtained without treatment. Consistent with the assertion of Simon et al. (1980) that sweetness is one of the most valued characteristics of carrots, the carrot samples studied with high sweetness scores were mostly high in carbohydrate content as found in this study. We also found in the present study that total carbohydrate are correlated to sweetness. Indeed, many authors have found that there is a relationship between the sensory quality of vegetables and their nutritional value (Fillion and Kilcast 2002; Gajewski and Arasimowicz 2004; Zhao et al.

Table 6 Correlation between nutritive value and sensory attributes

Variables	Total carbohydrates	Total carotenoids	Reducing sugars	NDF	ADF	Skin color	Colour of the longitudinal section	Sweetness	Hardness	Crispness	Crunchiness	Juiciness
Total carbohydrates	1											
Total carotenoids	− 0.125	1										
Reducing sugars	0.071	− 0.137	1									
NDF	0.079	− 0.045	0.011	1								
ADF	0.162	− 0.019	− 0.095	0.886*	1							
Skin colour	− 0.031	0.484*	− 0.057	0.111	0.111	1						
Colour of the longitudinal section	− 0.014	0.414*	0.004	0.055	0.082	0.935*	1					
Sweetness	0.447*	− 0.281	− 0.012	-0.011	-0.014	0.002	0.108	1				
Hardness	0.121	0.002	0.159	0.333*	0.318*	-0.056	− 0.036	− 0.090	1			
Crispness	0.374*	− 0.207	0.028	− 0.035	-0.122	-0.132	− 0.135	0.533*	− 0.277	1		
Crunchiness	0.087	0.200	0.000	− 0.085	-0.173	0.215	0.105	0.084	− 0.245	0.471*	1	
Juiciness	− 0.020	− 0.163	− 0.112	− 0.092	0.040	0.006	− 0.033	0.006	− 0.262	− 0.013	− 0.113	1

NDF neutral detergent fibre, *ADF* acid detergent fibre

* Variables are significantly correlated with each other at the 5% probability level

2007). Furthermore, the amount of sugar seems to be higher in carrot samples grown with organic fertilizer compared to carrot samples grown with chemical fertilizer (Lieblein 1993; Hogstad et al. 1997).

The sensory quality of carrots is one of the aspects allowing the quality analysis of carrot samples. However, this aspect can be influenced by pre-harvest factors among which varietal choice is the most important of all (Seljasen et al. 2013). Among the sensory quality attributes selected by the panellists in this study, the results showed that these are significantly dependent on the variety grown. It is thus possible that the best overall acceptability and preference scores for all the sensory parameters studied observed with the *New Kuroda*, *Pamela*+and *Vanessa F1* varieties may be related to their physiological development mechanism dictated by the information contained in their genetic material. These carrot varieties were able to adapt to the environmental factors to which they were subjected in order to synthesise compounds that are essential for their organoleptic acceptability. Indeed, during the growth and development of carrots, quality can be affected by genetic variations and climatic conditions (temperatures, light intensity and rainfall) (Seljasen et al. 2013; Sulaeman et al. 2010). This result is therefore similar to that of previous work showing *New Kuroda* given the best sensory properties of carrot independent of the dose of fertilizer applied (Djoufack 2018).

The results of the evaluation of the influence of fertilization and variety on the sensory quality of carrots showed significant differences for attributes such as carrot odour, sweetness, orange colouration of the skin and longitudinal section, overall score and preference of those carrot samples evaluated. Such results could point to variety-specific response mechanisms of carrots subjected to different fertilizers. In addition, the significant existence of sensory characteristics could be related to the types of genetic traits of the variety at the time of its creation or improvement. Indeed, genetic background seems to be one of the most important factor under human control capable of modifying the nutritional and sensory aspects of carrots (Seljasen et al. 2013). However, the observation that after analysis of the recorded scores, *Madona* treated with 600 kg ha^{-1} of chemical fertilizer was significantly less preferred than *New Kuroda* treated with 10 t ha^{-1} of chicken manure and the untreated variety *Vanessa F1* could be explained by considering that *New Kuroda* and *Vanessa F1* synthesize the compounds responsible for the best organoleptic appearance when fertilized with organic fertilizer or not respectively. In fact, although fertilization is a factor that affects the sensory quality of carrots (Seljåsen et al. 2013), many authors have shown that carrots grown with organic fertilizers were better appreciated than those grown with chemical fertilizers (Wrzodak et al. 2012; Djoufack 2018; Haglund et al. 1999; Rembialkovska 2003).

Carrot consumption has increased in recent years due to its recognition as a better source of nutrients (Nakalembe et al. 2015). With the exception of moisture and organic matter contents, the results showed that the nutrient contents of carrots were significantly affected by the types of fertilizers used during production. In this study chicken manure at the doses of 5 t ha^{-1} and 10 t ha^{-1} significantly increased the ash content of the carrot samples analysed. In fact, ash is an inorganic residue obtained after removal of water and organic matter by heating in the presence of oxidising agents. It provides a measure of the total amount of minerals present in the core. The result we have obtained could therefore be explained by the fact that chicken manure, which have a certain amount of minerals in their chemical composition, combine their nutrient composition with that of the soil to improve the physicochemical properties of the soil. Once the physico-chemical composition of the soil is improved, the soil becomes conducive for nutrient retention by the carrot plant and consequently leads to an increase in the mineral content within the plant; whereas this whole process could not be observed with chemical fertilizer, which only supplies macro-nutrients to the soil for plant growth (Sanwal et al. 2007; Adeleye et al. 2010). Indeed, chicken manures have the property of increasing the organic matter contents of the soil and increasing the soil nutrient holding capacity of the plant (Agbede et al. 2014).

Protein levels in carrot samples provide information on the levels of nitrogenous compounds in this vegetable in that the latter are involved in their synthesis. The highest levels of protein were mostly obtained with treatments such as 10 t ha^{-1} chicken manure, 300 kg ha^{-1} and 600 kg ha^{-1} of chemical fertilizer. Such a result would justify a significant supply of nitrogenous elements involved in the synthesis of proteins in the carrot plant by these types of fertilizers. It could be that the dose of 10 t ha^{-1} of chicken manure was sufficient to provide a good amount of nitrogenous elements to the plant to have had a similar effect to the doses of chemical fertilizers whose nitrogenous elements are rapidly assimilated by the plant. This is because, an increase in the application of nitrogenous fertilizers is directly related to an increase in the rate of nitrogen release and the synthesis of amino acids which enter into the physiological mechanisms of protein synthesis (Rendig 1984; Hernández et al. 2016). The main compound responsible for obtaining these high levels of protein with these fertilizers would be the nitrogen supplied in the amount necessary for the synthesis of nitrogenous compounds. Indeed, the nitrogen contained in fertilizers, especially inorganic fertilizers, is an important macronutrient for the plant and is a key factor for the synthesis of amino acids, which are the constituents of proteins and enzymes (Singh and Singh 2022).

Lipids are compounds that are part of the cell structure and they play an important role in the functioning of the organism. After analysis of the lipid contents obtained after fertilization, it was observed that these contents fluctuated between 0.15 ± 0.05 g/100 g DM and 0.23 ± 0.05 g/100 g DM. This variation in lipid contents is lower than the contents found by Coulibaly et al. 2018 in Ivory Coast and (Keertikumari et al. 2019) in India. The levels found by the latter were 1.40–2.04 g/100 g and 0.79–0.84% respectively. This non-correlation in content could be explained by the existence of a difference in the chemical composition of the soils on which the cores were grown. Also the variation in climatic conditions in the growing area and the varietal choice. According to Seljasen et al. (2013), genetic variability and environmental conditions to which crops are subjected affect the nutritive value of the crop.

Carrot roots are excellent sources of carbohydrates for consumers. Carbohydrate levels in carrot roots are generally affected by many factors, among which fertilization is prominent (Singh et al. 2012). In this study, where several types of fertilizers were used, the results show that these types of fertilizers significantly affected the total carbohydrate contents determined. The fact that the unfertilized sample had a significantly higher carbohydrate content than those obtained with 300 kg ha^{-1} and 600 kg ha^{-1} of chemical fertilizer could be related to excessive nitrogen and insufficient potassium inputs from these chemical fertilizer doses that did not meet the nutrient demand necessary for translocation of carbohydrate compounds from the leaves to the carrot roots. This is because these two macronutrients are predominantly involved in carbohydrate synthesis: nitrogen and potassium. Indeed, it has been shown that adequate nitrogen and potassium supply is essential for obtaining root vegetables with high sugar yields, particularly due to the presence of potassium (El-Sarag and Moselhy 2013; Gocan et al. 2013). However, the result that chicken manure led to the same effects as in the control would be parallel to that of Gocan et al. 2013 who found that organic fertilizer resulted in carrots with higher carbohydrate contents than inorganic fertilizer. However, the variation in carbohydrate contents 6.23 ± 0.70 g/100 g DM to 7.03 ± 0.92 g/100 g DM obtained in this study is approximately similar to that obtained by Coulibaly et al. 2018 and (Boadi et al. 2021) where they found a variation of 5.62 to 6.71% and 6.25 to 8.39% respectively.

The finding that chicken manure at 5 t ha^{-1} had the highest content of reducing sugars compared to the other treatments could be explained by the fact that chicken manure at a moderate dose would activate the developmental processes of the carrot plant by promoting the accumulation and storage of simple sugars. Moreover, chicken manure would allow a better availability and absorption of potassium which, in the presence of other major nutrients such as nitrogen and phosphorus, would favour the photosynthesis process and consequently the storage of simple sugars in the carrot root. Indeed, according to Jones (1982), potassium is involved in physiological processes of the plant such as photosynthesis and translocation of sugars. An increase in reducing sugar content observed after application of chicken manure, which is an organic fertilizer, is in agreement with the results of Cacek and Lagner (1986) and (Raupp 1996) who found in their work that reducing sugar contents increased in carrot roots when grown with organic fertilizer.

Carrots are consumed cooked or raw in the daily diet as they are a better source of carotenoids among which ß-carotene (provitamin A) which is converted to vitamin A in the body (Sarhad 2007). Therefore, total carotenoids were determined in this study in order to assess the level of impact of fertilization on their accumulation in the carrot root. The results of this work showed that chicken manure at 10 t ha^{-1} significantly increased carotenoid contents in the sense that this treatment had the highest carotenoid content compared to the control which had the lowest carotenoid content. Such result would be related to the growth factors brought by chicken manure to the soil which would then help the carrot plant during its development processes to accumulate more nutrients including carotenoids in its roots (Clotault 2009). Indeed, according to Tatjana et al. (2012), carotenoid levels in carrots depend on growing conditions such as temperature, light intensity and fertilization. These results are therefore in agreement with those of Kipkosgei et al. (2003) and (Gatsinzi et al. 2016) who showed in their work that increasing the doses of manure allowed an increase in carotenoid contents in carrot roots.

A high crude fibre content facilitates the digestive process in humans and livestock and prevents constipation (Hanif et al. 2006). Foods rich in fibre are known to prevent many diseases, including colon cancer. Dietary fibres also play a role in stimulating the growth and maintaining the balance of intestinal bacteria, thus preventing dysbiosis (Tomasello et al. 2015). Identifying foods with high dietary fibre content would be essential in order to promote high consumption by the population. With this in mind, fibre levels were determined in this study with a focus on a few types of soluble and insoluble fibre. If we add up the fibre types determined in this work, we find that the levels are around 6%. The fibre contents found in this study are lower than those found by Boadi et al.

(2021) and (Gazalli et al. 2013) who obtained contents around 7.18 to 8.87% and 24.66% respectively.

In the context of identifying carrot varieties with not only good agronomic performance but also good nutritional characteristics, this study was undertaken to determine the variation in nutritional value of carrots using five carrot genotypes commonly grown in Cameroon. It has been shown that besides edaphic and environmental factors, genetic factors affect the nutritional value of carrots (Singh et al. 2012; Mateljan 2007). The results obtained in this study show that the nutritional value of carrots depends significantly on the varietal choice. Although, the moisture contents obtained with the varieties studied were not significantly different from each other, those obtained with the varieties *New Kuroda* (91.48 ± 1.77%) and *Amazonia* (91.76 ± 1.54%) are nevertheless higher than the contents obtained with the same varieties studied by Boadi et al. (2021) in Ghana where they found 74.04% and 69.06% for the varieties *Kuroda* and *Amazonia* respectively. Similarly, the moisture content (91.62 ± 1.22%) obtained in this study with the variety *Pamela* + is higher than that obtained by Coulibaly et al. 2018 in Ivory Coast who found a moisture content of 87.2% with the same variety. In fact, the moisture contents obtained in this work are not similar to those found by many authors among whom (Gopalan et al. 1991; Cohen et al. 2009; Arscot and Tanumihardio 2010). These differences in values could be explained by the existence of differences in soil structure, nutrient composition and organic matter content of the soils on which these carrot varieties were grown. In addition, climatic conditions such as rainfall and temperature must also be considered as factors responsible for variations in water retention by carrot plants. Indeed, soil structure, porosity, organic matter maintenance and environmental conditions affect the development of carrots (Lieblein 1993; Khan et al. 2010). A possible explanation for the high ash contents obtained with the varieties *New Kuroda* (1.08 ± 0.25) and *Madona* (1.08 ± 0.23) is that these varieties, by adapting to the environmental conditions to which they were subjected during cultivation, they have developed mechanisms for storing a large amount of minerals in their vessels, especially when considering that mineral accumulation in carrots can be genetically dictated. These ash content results are in agreement with those found by Coulibaly et al. 2018 where the varieties *Madona* and *Amazonia* presented the highest ash contents while the variety *Pamela* + presented the lowest ash content. The probable reason why the highest protein content was obtained with the variety *Vanessa F1*, would be related to the fact that this variety was derived from a genetic improvement process based on already existing varieties. This is because its introduction among the most cultivated varieties in Cameroon is recent. Nevertheless, the variations in protein content obtained in this study (0.69 ± 0.18 to 0.86 ± 0.15) are lower than those found by Coulibaly et al. 2018 and (Boadi et al. 2021) where these contents fluctuated from 2.71 to 3.66% and from 6.46 to 10.73% respectively. These differences could be related to the types of fertilizers used in carrot cultivation. In the sense that nitrogen inputs would increase the rate of proteins synthesis in the carrot plant. On the other hand, the protein contents obtained in this work are similar to those found in the work of Gopalan et al. 1991 and (Cohen et al. 2009) who indicated at the end of their work that the protein contents varied from 0.7% to 1.1%.

With regard to lipid content, the fact that the *New Kuroda*, *Pamela* + and *Vanessa F1* varieties had the highest lipid content is thought to be related to the expression of genes involved in the synthesis of this macronutrient which increased the storage of this macronutrient in their roots at maturity. This result is relatively close to that of Gopalan et al. 1991 who found that the lipid content in carrot is 0.2%. However, it is not in agreement with those of Coulibaly et al. 2018 and (Boadi et al. 2021) who obtained variations from 0.79 to 0.84% and from 1.97 to 4.31%. These differences could be explained by different fertilizer uses during cultivation in addition to the responses of the cultivated varieties to climatic conditions. Our results possibly show that the types of fertilizers in this study lowered the lipid content of the cultivated carrot samples and therefore the latter would be low in lipids. The total carbohydrate contents obtained in this study varied from 6.28 ± 1.12 to 6.80 ± 0.92%. This result is slightly similar to those obtained by Coulibaly et al. 2018 and (Boadi et al. 2021) who found variations of 5.62% to 6.71% and 6.25% to 8.39% of total carbohydrate contents respectively.

Reducing sugars are mostly simple sugars which are responsible for the taste quality of carrots. The content of reducing sugars is generally related to the type of variety grown. The results obtained in this work showed that these contents vary greatly from one carrot variety to another. However, the reasons why the varieties *Vanessa F1* and *New Kuroda* showed the highest levels of reducing sugars could be related to the physiological mechanisms of these varieties in accumulating these types of sugars in contrast to the other varieties. Furthermore, this result is in harmony with the reason that these carrot varieties recorded the highest scores for sweetness. The results of our work are thus similar to those of Djoufack (2018) who showed that reducing sugar contents vary according to the genotype of the variety of carrot used. The variation of carotene contents in carrots depends on the genotype (Gabelman 1974; Rodriguez-Amaya 1993), on the climate or the geographical site of production (Simon et al. 1982).

The variation in carotenoid contents was also determined in this work and our results showed that these contents vary significantly according to the genotype of the carrot grown. Among these cultivated carrot varieties, the highest carotenoid contents were obtained with the varieties *Madona* and *New Kuroda*, while the lowest content was obtained with the variety *Pamela+*. These results indicate a predominantly genetic dependence of carotenoid levels in carrots. Our results are in line with those obtained by several authors who, although working with different carrot varieties than those studied in this work, also found that carotenoids contents are strongly related to the type of carrot cultivar used (Rendig 1984; Bystrická et al. 2015; Kiraci and Padem 2016).

In general, the highest levels of the dietary fibre types determined in this study were obtained with the variety *Amazonia*. This result parallels that of Boadi et al. (2021) who found that among the three carrot varieties studied in Ghana, the *Amazonia* variety had the highest fibre content. This similarity could be due to better expression of the genes of this variety in the development of carrot walls irrespective of the locality of cultivation and consequently a high dietary fibre content.

The results of the interactions between fertilizer types and carrot varieties on the determined nutrient parameters showed that these combinations significantly influence these parameters and the levels found vary strongly from one combination to another. These results could prove the existence of a variability in the capacity of absorption and accumulation of nutrients by the carrot plant, according to the types of varieties and fertilizers used during cultivation and also according to the type of climate prevailing during cultivation. Indeed, several studies have shown that the nutritive value of carrots is highly dependent on agronomic, environmental and genetic factors (Anal 2013; Singh et al. 2012; Kaack et al. 2001; Rembiałkowska 2007; Smoleń et al. 2012; Ahmad et al. 2019; Geoffriau 2020).

Conclusion

This study showed that fertilizers, carrot varieties and their combination significantly affect the sensory quality (carrot odour, sweetness, orange coloration of the skin and longitudinal section, overall score and preference) and nutritional value (ash, proteins, lipids, total carbohydrate, carotenoids, reducing sugars, NDF, ADF, ADL, cellulose and hemicellulose) of carrots in production system in Cameroon. The best scores of sensory quality were recorded with the *New Kuroda* variety treated with 10 t ha^{-1} of chicken manure and the unfertilized *Vanessa F1* variety. In order to obtain carrots with good nutritional values, the *New Kuroda* carrot variety should be grown with a combination of 300 kg ha^{-1} chemical fertilizer + 10 t ha^{-1} of chicken manure; the *Pamela+* variety should not be fertilized; the *Madona* variety should be fertilized with 10 t ha^{-1} chicken manure, 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} of chicken manure or not fertilized; the variety *Amazonia* should be fertilized with 300 kg ha^{-1} chemical fertilizer and the variety *Vanessa F1* should be fertilized with a combination of 600 kg ha^{-1} chemical fertilizer + 5 t ha^{-1} chicken manure.

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Author contributions
MMTD collected the plant material and performed the experimental trial. MMTD, EBK and FNZ conceived of the study, analyzed data and interpreted results. MMTD wrote the paper. EMFK, MA and PMK reviewed the manuscript prior to submission and provided valuable comments on the interpretation and presentation of results. All authors read and approved the final manuscript.

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The data set used/analyzed during the current study is available from the corresponding author on reasonable request.

Declarations

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The authors declared that they have no competing interest in connection with the evaluated manuscript.

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