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Original Article

# Assessment of carotenoids, capsaicinoids and ascorbic acid composition of some selected pepper cultivars (*Capsicum annuum* L.) grown in Turkey

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**Abstract**

Carotenoid, capsaicinoid and ascorbic acid composition of ripe fruits of five *Capsicum annuum* cultivars (730 F1, 1245 F1, Amazon F1, Serademre 8 and Kusak 295F1), grown as principle breeding material in Turkey, were quantitatively investigated by means of HPLC technique. Seven main carotenoids, five analogues of capsaicinoids and ascorbic acid were quantified in the fruits grown for 2 year replication. From the capsaicinoids and carotenoids data, Scoville Heat Unit (SHU) and retinol activity equivalent (RAE) values of the fruits were also calculated, respectively. The findings determined that the cultivars of 730 F1 and 1245 F1 had higher carotenoids (2310–2390 mg/kg in dry basis), capsaicinoids (471.3–688.1 mg/kg in dry basis), vitamin A (218.8–243.0 μg RAE/100 g in wet basis) and vitamin C (63.1–64.9 mg/100 g in wet basis) content, without any significant difference among each of them. Furthermore, the cultivars which had higher capsaicinoids contents had higher ascorbic acids content as well. With their high nutritional and functional components, the cultivar of 730 F1 and 1245 F1 can be considered to be selected breeding material for cultivar development.
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*Keywords:* *Capsicum annuum*; Carotenoids; Capsaicinoids; Ascorbic acid; Cultivars

## 1. Introduction

The mature fruit of red pepper (*Capsicum annuum* L.) is consumed as a result of increasing demand, in the form of fresh and processed colorants, such as paste, paprika and oleoresin. Their popularity stems from the combination of color, taste and pungency (Biacs et al., 1993; Ittah et al., 1993; Howard et al., 1994; Hornero-Mendez at al., 2000).

The intense and characteristic red color of *Capsicum* fruits is principally due to the pigments of capsanthin and capsorubin (Ittah et al., 1993; Minguez-Mosquera and Hornero-Mendez, 1994a; Levy et al., 1995; Minguez-Mosquera and Perez-Galvez, 1998; Kim et al., 2004). They belong to carotenoids, which are present in the chloroplast of red pepper as partially esterified with fatty acids. The carotenoids are $C_{40}$ isoprenoids containing 9 conjugated double bonds in the central polyenic chain, with different end groups ($\beta$, $\varepsilon$, $\kappa$, 3-hydroxy-5,6-epoxide) which change the chromophore properties of each pigment into a red or yellow classification. The yellow fraction mainly comprises of zeaxanthin, violaxanthin, antheraxanthin, $\beta$-cryptoxanthin, $\beta$-carotene and capsolutein, which are biosynthetic precursors of the red fraction. Of these pigments, only $\beta$-carotene and $\beta$-cryptoxanthin have vitamin A activity (Minguez-Mosquera and Hornero-Mendez, 1994a, 1997; Hornero-Mendez et al., 2000). Vitamin A activity of these carotenoids is affected by absorption and conversion by oxygenase enzymes which cleave carotenoids to retinol (Simpson and Chichester, 1981). Thus, they are represented as being retinol equivalent (RE). In the United State of America, vitamin A values now are expressed as retinol activity equivalents (RAE), rather than RE (Wall, 2006). 1 RAE is equivalent in vitamin A activity to 1 μg retinol, 2 μg $\beta$-carotene dissolved in oil, 12 μg $\beta$-carotene or 24 μg other provitamin A carotenoids in mixed food (IOM, 2001).

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Carotenoids play an important role in the human health for their antioxidant and free-radical scavenging effect; i.e. prevention of certain types of cancer, cardiovascular disease, eye disorders, skin degeneration and aging (Olson, 1989; Zhang et al., 1991; Edge et al., 1997; Russo and Howard, 2002).

The group of pungent components peculiar to the fruits of *Capsicum* plants is called capsaicinoids. All of the identified capsaicinoids in the *Capsicum* fruits are vanillylamides of branched fatty acids, with 9–11 carbons, of which capsaicin (vanillylamide of 8-methylnontrans-6-enoic acid) and dihydrocapsaicin (vanillylamide of 8 methylnonanoic acid) occur in quantities greater than 80%. The remaining derivatives are found in very small amounts (Krajewska and Powers, 1988; Thomas et al., 1998; Perucka and Materska, 2001). It has been reported in recent studies that each capsaicinoid analogue is responsible for different burning sensation in the mouth. Capsaicin and dihydrocapsaicin are the most pungent capsaicinoids, with the equivalent value of $16.1 \times 10^6$ Scoville Heat Unit (SHU) (Krajewska and Powers, 1988; Dong, 2000). These compounds are produced in glands on the pepper's placenta and the white ribs that run down the middle and along the sides of a pepper. Hence glands and white ribs are the hottest parts of a red pepper. Since the seeds are in close contact with the ribs, they are also often hot (Bosland, 1992; Dong, 2000). The capsaicinoids are synthesized through the cinnamic acid pathway, and it is thought that their degradation is aided by the action of peroxidase (Contreras-Padilla and Yahia, 1998).

Capsaicinoids also have strong physiological and pharmacological properties. In addition to its widespread use as a neuropharmacological tool, capsaicin is of great medical value and it has been reviewed to evaluate its effect in treatment of painful conditions such as: rheumatic diseases, cluster headache, painful diabetic neuropathy, postherpetic neuralgia, etc. (Tsuchiya, 2001). They decrease the myocardial and aortic cholesterol levels even when used at low levels in the diet. In recent years, capsaicinoids have been studied and found to be effective treatment for a number of sensory nerve fiber disorders including arthritis, cystitis, human immunodeficiency virus, etc. (Robbins, 2000; Perucka and Materska, 2001). They have also been reported as having an antioxidant and antibacterial effect on a certain group of bacteria (Henderson and Slickman, 1999; Dorantes et al., 2000).

Vitamin C is another functional and nutritional constituent of pepper fruit, well-known as being an antioxidant and a biologically active compound (Robinson et al., 1982; Simonne et al., 1997; McCall and Frei, 1999; Rietjens et al., 2002).

The above-mentioned composition of *Capsicum* fruit can vary greatly by genotype and maturity. The content of carotenoids and ascorbic acid of pepper fruit increases upon maturation (Howard et al., 1994; Simonne et al., 1997; Markus et al., 1999). They are also influenced by growing and processing conditions (Minguez-Mosquera and Hornero-Mendez, 1997; Hornero-Mendez et al., 2000; Russo and Howard, 2002; Topuz and Ozdemir, 2003, 2004).

Today, breeding studies are usually focused on morphology, yield, pests, resistance to diseases and salinity, etc. However, the studies should be also involved in nutritional and functional properties of the peppers. Therefore, the present study was conducted to determine the carotenoids, capsaicinoids and ascorbic acid contents of the ripe fruit of the five pepper cultivars used as breeding materials.

## 2. Materials and methods

### 2.1. Materials

The study was carried out on pepper (*Capsicum annuum* L.) cultivars of 730 F1, 1245 F1, Amazon F1, Serademre 8 and Kusak 295 F1 grown at the Experimental Station of West Mediterranean Agricultural Research Institute, Antalya, Turkey. The plants had been grown for 2 consecutive years in a glasshouse with the density of 3000 plants per $km^2$ and they had been treated by the same commercial agricultural practices. Each year, a sufficient number of entirely red pepper pods (approximately 1 kg in fresh weight) were individually hand harvested from 20 to 25 plants for every cultivar. Care was taken in harvest that the fruits were of the same generation, maturation and of similar size. After harvest, the samples were put into polyethylene bags and immediately transported to the laboratory and stored at −18 °C until extraction for HPLC analyses.

The pepper pods from same cultivar were randomly separated into four groups for analyses of the main components (carotenoids, ascorbic acid and capsaicinoids) and water. For each group of the components, extractions were performed on the puree samples, processed by a hand blender for 5 min from pepper pods with seeds after defrosting, rinsing, wiping removing the stalks and chopping. These procedures were conducted in laboratory under gloomy condition. Duplicate injections were done to the HPLC from every extract. These procedures were replicated on the samples for 2 consecutive years.

The dry matter of each sample was gravimetrically determined by drying the sample in an oven at 75 °C until constant weight was achieved.

### 2.2. Analyses of carotenoids

The carotenoids analyses were carried out according to a method used in previous studies (Minguez-Mosquera and Hornero-Mendez, 1993).

Extraction of carotenoids from 10 g of fruit paste was performed with acetone using the Ultra Turrax homogenizer until no more color was extracted. Then the acetone was evaporated (at 50 °C and 500 mmHg vacuum) until a 50 mL final volume was attained. The concentrate was transferred into a separatory funnel with 100 mL of

diethyl ether and 100 mL of sodium chloride solution (10%) for phase separation. The supernatant was then washed with 100 mL of anhydrous $Na_2SO_4$ (2%) solution to remove all of the remaining water. For the saponification reaction at room temperature, 50 mL potassium hydroxide solution (10%) in methanol was added and shaken vigorously before being left in a dark place for 1 h. The solution was separated by adding 100 mL of sodium chloride solution (10%) at the end of the saponification process. For subsequent quantification, 500 μL of β-apo-8′-carotenal solution (500 μg/mL) in 40–60 °C light petroleum ether was added, and the aqueous phase was discarded. The organic phase was first washed several times with 100 mL distilled water, until the wash was neutral, then once in 100 mL of anhydrous $Na_2SO_4$ (2%) solution. After that, the diethyl ether was evaporated (at 30 °C and 500 mmHg vacuum) to dryness using a rotary evaporator (Janke Kunkel), and the pigments were dissolved in acetone up to a volume of 100 mL and passed through the 0.45 μm membrane filter (Millipore) before injection.

The chromatographic separation was performed on a reversed-phase column (Nucleosil 5 $C_{18}$, 250 × 4 mm i.d.). The binary gradient (acetone:water at the beginning 75:25) elution was run by means of a solvent delivery system (Varian 9010) at the flow rate of 1.5 mL/min. The gradient was initiated with the beginning proportion for 5 min, then linearly increased to 95:5 for 5 min, and subsequently maintained at this level for 10 min. At the end of the analysis, the column was washed with acetone for 3 min, and conditioned with the initial proportion for 10 min. Detection was performed at 450 nm with the UV detector (Varian 9050). A guard cartridge (Nucleosil 5 $C_{18}$ 4 × 4 mm i.d.) was used to protect the main column for each of the ten samples. Chromatographic separation of the specific samples was performed in duplicate at room temperature, with a 20 μL injection volume.

Identification of the pigments was carried out according to the method of Minguez-Mosquera and Hornero-Mendez (1993), which consists of thin layer chromatographic purification and identification. The purified carotenoid solutions were used to differentiate each peak in the HPLC chromatogram.

### 2.3. Analyses of capsaicinoids

Capsaicinoids were extracted from the samples of red pepper pastes by applying the technique described by previous study (Collins et al., 1995).

The capsaicinoids were extracted from 2 g of paste sample in 12 mL acetonitrile by heating at 80 °C for 4 h. Suspensions were periodically shaken every 30 min throughout the extraction process. The suspended material was allowed to cool and settle. The supernatant was filtered into a 2 mL glass vial using 0.45 μm membrane filter (Millipore) and used for HPLC injections.

Liquid chromatography was performed using a Varian HPLC solvent delivery system (9010) equipped with a fluorescence detector (Varian 9070) and Star software for data processor. The separation was performed on a Nucleosil 5 $C_{18}$ column (250 × 4.6 mm i.d.) coupled with a Nucleosil 5 $C_{18}$ guard column (4 × 4.6 mm i.d.).

The following HPLC operating condition, used by Peusch et al. (1997), was employed. The eluent was a mixture of acetonitrile/water/acetic acid (100:100:1) at a flow rate of 1.2 mL/min. The fluorescence detector was set at 280 nm excitations and 320 nm emissions. Injection volumes, run time and temperature were 20 μL, 23 min and 20–22 °C, respectively.

Standards of capsaicin (98%), dihydrocapsaicin (90%) and mixture of capsaicinoids (60% capsaicin) of Sigma Chemical Co. (St. Louis, MO) were used for retention time verification and quantification.

### 2.4. Analysis of ascorbic acid

In order to determine the ascorbic acid content, 20 g samples were homogenized with 80 mL % 3 metaphosphoric acid containing $10^{-6}$ M ethylenediaminetetraacetic acid and $10^{-7}$ M diethyldithiocarbamic acid by using Ultraturrax and of 30 mL slurry was centrifuged at 10 000 rpm for 10 min at 4 °C. Then the supernatant was flushed through Sep-pak $C_{18}$ cartridge (Alltech), preconditioned with 3 mL % 3 metaphosphoric acid solution, and 0.45 μm membrane filter, respectively. Quantification of ascorbic acid was made by external standard of ascorbic acid (Merck) dissolved in the mobile phase.

The HPLC system consisted of Varian 9010 Solvent Delivery System and Varian 9050 UV–Visible detector (254 nm). The Nucleosil 5 $C_{18}$ (250 × 4.6 mm ID) column was used. For elution, potassium dihydrogen phosphate solution (0.2 M), adjusted to final pH value of 2.2 with *o*-phosphoric acid, was used at a flow rate of 0.7 mL/min. Injection volumes, run time and temperature were 20 μL, 15 min and 20–22 °C, respectively.

### 2.5. Statistical analysis

Data represent the mean of two replicate analyses by years. Analysis of data was performed using the Statistical Analysis System software (SAS for Windows, version 7) to determine the effects of cultivar on the dependent variables. Mean values were compared using the Duncan's Multiple Range Test at 5% level.

## 3. Results and discussion

### 3.1. Carotenoids of pepper cultivars

It is known that the carotenoid level in the *Capsicum* fruit depends primarily on fruit maturity, and this dependence can vary among the cultivars. In the present study, the *Capsicum* fruits were sampled at the same maturity of the totally red color, and at almost the same moisture level (Table 1) for every cultivar.

With the HPLC separation, seven principle carotenoid components were identified in all samples of the five cultivars. Table 2 shows the carotenoid concentration of the ripe fruits of the *Capsicum* cultivars grown in Turkey. Among them, capsanthin is the major compound for all cultivars, and represents more than 50% of the total carotenoids content which coincided with results (51%–59%) of other studies (Minguez-Mosquera et al., 1994; Minguez-Mosquera and Hornero-Mendez, 1994b). In the current study besides capsanthin, capsorubin, capsolutein, violaxanthin, zeaxanthin, β-carotene and β-cryptoxanthin were also quantified. In a previous study, the same pigments were quantified at higher concentration for the Bola and Agridulce varieties and there are also considerable differences among these varieties (Minguez-Mosquera and Hornero-Mendez, 1994b). For instance, in capsanthin concentrations, there is an almost twofold difference between the Bola and Agridulce varieties under the same growing condition and at the same level of maturity. In the current study, all carotenoids were quantified in a wide range of concentrations among the cultivars during 2 consecutive growing years. However, there is no significant difference in the present results among the cultivars except for β-carotene. Only the β-carotene contents of the fruits of 730 F1 and 1245 F1 are significantly ($P<0.05$) higher than those of the others. It was also interesting to emphasize that β-cryptoxanthin content had the lowest variation among all cultivars. This finding probably means that the synthesis of β-cryptoxanthin in the *Capsicum* fruit is independent from the cultivar.

When the cultivars were compared by red, yellow and total carotenoids, they did not show any significant differences (Table 3). In general, the red fraction represents more than 60% of the total carotenoids for all cultivars. Considering the ratio of red to yellow, all cultivars, except Amazon F1, corresponded with more than 1.2. This value was determined to be less than 1 for only Amazon F1. For different several cultivars, the fraction of red to yellow carotenoids was also reported to be between 1.01 and 1.81 at red maturity stage (Minguez-Mosquera and Hornero-Mendez, 1994b; Hornero-Mendez et al., 2000; Russo and Howard, 2002). The difference in Amazon F1 might be attributed to the genetic diversity of the cultivars. However, considering the fact that the apparent color of the fruit may not reflect equal maturity, the difference therefore may also be attributed to maturity differences.

### 3.2. RAE and ascorbic acid (vitamin C) contents of pepper cultivars

Of the carotenoids, only β-carotene and β-cryptoxanthin have vitamin A activity (Minguez-Mosquera and Hornero-Mendez, 1994b, 1997; Scott and Rodriquez-Amaya, 2000; Perez-Galvez et al., 2005). Vitamin A activities of the samples were determined in RAE with conversion factors (μg β-carotene/12 + μg β-cryptoxanthin/24) of provitamin A carotenoids recommended by Food and Nutrition Board (IOM, 2001). The RAE value of the samples ranged between 148.1 and 243.0 μg RAE/100 g and averaged

Table 1
Dry matter content of the ripe fruit of pepper cultivars at the harvest (%)

| Cultivar (origin) | Dry matter content |
|---|---|
| 730 F1 (Turkey) | 13.30±1.90 |
| 1245 F1 (Turkey) | 14.07±1.50 |
| Amazon F1 (Netherlands) | 13.49±2.78 |
| Serademre 8 (Turkey) | 15.04±0.30 |
| Kusak 295 F1 (Turkey) | 13.71±1.24 |

Table 3
Red, yellow and total carotenoids of the ripe fruits of five *Capsicum annuum* cultivars (mg/kg dry matter)

| Cultivar | Red | Yellow | Total |
|---|---|---|---|
| 730 F1 | 1340±93.1 | 1050±47.4 | 2390±140.5 |
| 1245 F1 | 1320±233.9 | 984.5±182.1 | 2310±415.9 |
| Amazon F1 | 874.3±118.8 | 939.6±159.8 | 1810±278.6 |
| Serademre 8 | 931.5±98.7 | 751.0±52.0 | 1680±150.7 |
| Kusak 295 F1 | 809.2±75.4 | 630.9±87.0 | 1440±162.4 |
| Statistical significance | NS | NS | NS |

The values are mean±standard error ($n=2$), NS: nonsignificant at $P<0.05$.
Red: capsanthin and capsorubin; Yellow: capsolutein, violaxanthin, zeaxanthin, β-carotene and β-cryptoxanthin.
The values of red and yellow carotenoids were estimated from raw values of individual carotenoid data.

Table 2
Carotenoids composition of the ripe fruits of five *Capsicum annuum* cultivars (mg/kg dry matter)

| Cultivar | Capsanthin | Capsolutein | Capsorubin | Violaxanthin | Zeaxanthin | β-Carotene | β-Cryptoxanthin |
|---|---|---|---|---|---|---|---|
| 730 F1 | 1270±89.4 | 267.4±5.6 | 67.2±3.7 | 101.1±8.8 | 409.9±55.0 | 120.3[a]±11.0 | 154.3±10.9 |
| 1245 F1 | 1270±217.8 | 278.2±60.9 | 58.6±16.0 | 89.3±19.3 | 327.1±108.1 | 124.5[a]±6.2 | 165.5±12.3 |
| Amazon F1 | 850.0±109.5 | 171.2±56.4 | 25.9±10.8 | 59.3±8.1 | 462.4±55.6 | 83.9[b]±15.3 | 163.0±24.6 |
| Serademre 8 | 891.5±95.2 | 222.3±36.3 | 40.0±3.5 | 64.3±8.5 | 280.0±0.7 | 69.5[b]±8.4 | 115.0±0.6 |
| Kusak 295 F1 | 769.0±71.3 | 181.4±22.9 | 40.2±4.1 | 50.3±9.6 | 212.8±38.4 | 72.9[b]±5.1 | 113.5±11.0 |
| Statistical significance | NS | NS | NS | NS | NS | * | NS |

The values are mean±standard error ($n=2$), NS: nonsignificant, *: significant at $P<0.05$.
The values in a column followed by the different superscript letters are significantly ($P<0.05$) different (Duncan's Multiple Range Test).

191.0 μg RAE/100 g (Table 4). Vitamin A activities of the fruits of 730 F1 and 1245 F1 were significantly ($P<0.05$) higher than those of the Serademre 8 and Kusak 295 F1. Naturally, there was a direct correlation between the values of β-carotene content and vitamin A activity. Hence, although the total carotenoids content of the fruit of 730 F1 was higher, the higher vitamin A activity belongs to the fruit of 1245 F1. The present findings are consistent with the results of previous studies (Howard et al., 1994; Minguez-Mosquera and Hornero-Mendez, 1997; Russo and Howard, 2002) for ripe fresh fruits when using the same conversion factor of retinol.

US Dietary Reference Intake (DRI) values for vitamin A, established by the Food and Nutrition Board of the Institute of Medicine, are 900 and 700 μg RAE/day for adult (ages 19–50 years) males and females, respectively (IOM, 2001). Based on these references values, consuming about 100 g fresh ripe fruits in a day would provide between 30% and 60% of US DRI values of vitamin A for an adult, depending on the cultivars and ripeness.

Ascorbic acid content of the cultivar of 1245 F1, Serademre 8 and 730 F1 varied between 57.5 and 64.9 mg/100 g in fresh sample. Among the cultivars, higher ascorbic acid content was determined in 1245 F1; however, there was no statistical ($P>0.05$) difference between ascorbic acid content of those cultivars. The ascorbic acid contents of the cultivars of 730 F1, 1245 F1 and Serademre 8 are similar with that of many different pepper cultivars studied by Howard et al. (1994) and Simonne et al. (1997). However for other cultivars in their studies, ascorbic acid contents were reported at higher levels in comparison with the present findings. The ascorbic acid contents of the cultivar Amazon F1 was lower than those of the other cultivars with the value of 15.2 mg/100 g. These differences can be reasoned by genetic diversity. However, minor differences in the extraction methods may be attributed to such differences in ascorbic acid results. These results can be considered in selecting breeding material by means of nutrition value.

US DRI values for vitamin C are 75 and 90 mg/day for adult males and females, respectively (IOM, 2000). Considering these values, consuming about 100 g fresh ripe fruits in a day would provide between 17% and 72% of US DRI values of vitamin C for an adult (ages 19–50 years) male, and 20% and 86% for an adult (ages 19–50 years) female depending on the cultivars and ripeness.

Table 4
The vitamin A activity (RAE) and ascorbic acid (vitamin C) content of the ripe *Capsicum* fruits

| Cultivar | Vitamin A (μg RAE/100 g fresh weight) | Ascorbic acid (mg/100 g fresh weight) |
|---|---|---|
| 730 F1 | $218.8^{a}\pm18.2$ | $63.1^{a}\pm10.6$ |
| 1245 F1 | $243.0^{a}\pm14.5$ | $64.9^{a}\pm10.5$ |
| Amazon F1 | $185.9^{ab}\pm31.0$ | $15.2^{c}\pm2.8$ |
| Serademre 8 | $159.2^{b}\pm10.9$ | $57.5^{ab}\pm10.1$ |
| Kusak 295 F1 | $148.1^{b}\pm12.1$ | $25.6^{bc}\pm0.5$ |
| Statistical significance | * | * |

RAE (retinol activity equivalent) = μg β-carotene/12 + μg β-Cryptoxanthin/24.
The values are mean ± standard error ($n=2$), *: significant at $P<0.05$.
The values in a column followed by the different superscript letters are significantly ($P<0.05$) different (Duncan's Multiple Range Test).

### 3.3. Capsaicinoids of pepper cultivars

Five analogues of the capsaicinoids were determined in varying concentration for the fruits of the cultivars. From these analogues, both capsaicin and dihydrocapsaicin represented more than 75% of the total capsaicinoids in the fruit of 730 F1, 1245 F1 and Serademre8 cultivars. Similar results had been previously reported by many authors for different *Capsicum annuum* varieties (Dong, 2000; Perucka and Oleszek, 2000; Perucka and Materska, 2001). However for the other cultivars in the current study, there was an almost opposite trend. Capsaicin could be barely determined as 15% in Amazon F1 and 34% in Kusak F1. Dihydrocapsaicin, in particular, could be expressed as trace amount in both cultivars. This finding is an identical characteristic among the cultivars. Homodihydrocapsaicin was noted as another major capsaicinoid analogue present in all of the cultivars. It was even determined to be the main component for the cultivar of Amazon F1 and Kusak 295 F1. Homocapsaicin and

Table 5
Capsaicinoids composition of the ripe fruits of five *Capsicum annuum* cultivars (mg/kg dry matter)

| Cultivar | C | DHC | HC | HDHC | NDHC | Total | SHU |
|---|---|---|---|---|---|---|---|
| 730 F1 | $307.7^{a}\pm45.4$ | $208.0^{a}\pm74.7$ | $19.5\pm4.5$ | $112.9^{a}\pm1.0$ | $40.0\pm18.0$ | $688.1^{a}\pm132.6$ | $9720^{a}\pm2061.8$ |
| 1245 F1 | $271.0^{a}\pm45.6$ | $123.4^{ab}\pm7.8$ | $20.1\pm4.8$ | $32.6^{c}\pm7.1$ | $24.4\pm4.3$ | $471.3^{ab}\pm45.6$ | $6980^{ab}\pm806.7$ |
| Amazon F1 | $16.0^{c}\pm2.5$ | $0.1^{b}\pm0.0$ | $17.0\pm3.5$ | $65.8^{b}\pm5.8$ | $10.2\pm0.1$ | $109.1^{cd}\pm12.0$ | $1000^{cd}\pm112.9$ |
| Serademre 8 | $149.2^{b}\pm19.8$ | $72.5^{b}\pm13.64$ | $14.2\pm0.9$ | $63.9^{b}\pm8.9$ | $15.8\pm5.8$ | $310.7^{bc}\pm15.3$ | $4300^{bc}\pm158.6$ |
| Kusak 295 F1 | $11.0^{c}\pm2.8$ | $1.7^{b}\pm1.6$ | $4.7\pm1.5$ | $15.4^{c}\pm5.4$ | $0.1\pm0.0$ | $32.9^{d}\pm11.3$ | $362.5^{d}\pm124.8$ |
| Statistical significance | ** | * | NS | ** | NS | ** | ** |

The values in a column followed by the different superscript letters are significantly ($P<0.05$) different (Duncan's Multiple Range Test).
The values are mean ± standard error ($n=2$), NS: nonsignificant at $P<0.05$, *: significant at $P<0.05$, **: significant at $P<0.01$.
C: capsaicin; DHC: dihydrocapsaicin; HC: homocapsaicin; HDHC: homodihydrocapsaicin; NDHC: nordihydrocapsaicin; SHU: Scoville Heat Unit.

nordihydrocapsaicin were the other capsaicinoids present in all the cultivars (Table 5).

The major capsaicinoid analogues were significantly different (capsaicin and homodihydrocapsaicin ($P<0.01$), dihydrocapsaicin ($P<0.05$)) among the cultivars. The highest amounts of capsaicinoids were found in the cultivar of 730 F1 and 1245 F1, and there were insignificant ($P>0.05$) differences between each other. The components of homocapsaicin and nordihydrocapsaicin are not different in the cultivars. Based upon this finding, it can be inferred that synthesis of these analogues is independent from the cultivars.

From the sensorial point of view, the present cultivars were also compared with the value of SHU, which was estimated by the method of Todd et al. (1977). The SHU values of the cultivars changed between 362.5 and 9720. Naturally, the cultivars which have higher capsaicin and dihydrocapsaicin contents result in higher SHU values. Consequently, the SHU value of the cultivars of 730 F1 and 1245 F1 were higher than those of other cultivars, without there being any statistical differences between each cultivar. Likewise, the lowest SHU value was calculated in the cultivar of Amazon F1 and Kusak 295 F1, and attributed to their low content of the capsaicinoids.

## 4. Conclusions

It can be deduced from the current study that the cultivars of 730 F1 and 1245 F1 are superior to the other cultivars in terms of carotenoids, capsaicinoids and ascorbic acid contents. It must be emphasized that the cultivar had higher capsaicinoids, had also higher ascorbic acid content and RAE value. Due to a lack of related literature on the cultivars, the current findings are essential as new information to the scientific database. The current study may contribute to the breeders in cultivar development not only in terms of their yield, cultivation cycle, production in cool area and resistance for disease and pests, but also in the nutritional and functional composition of the product.

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