Evaluation of three Chinese Varieties of Okra (*Abelmoschus esculentus* L) Cultivated in Egypt

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ABSTRACT

This study aimed to investigate the ability to cultivate the high-yield new Chinese okra varieties Yuncheng (Chinese 1), Xingyun (Chinese 2) and Red Chien (Chinese 3) in Egypt and compare their characteristics (chemical composition, Functional properties, antioxidant activity, and sensory properties) with characteristics of Egyptian okra cultivars (Balady and Roumy). The results appeared that all okra variety significantly differed in the plant height character. Also, the results showed that the Balady variety was late in flowering (took the maximum days to give flowers) followed by the Chinese variety Xingyun, while, Roumy and Chinese 1 varieties were early in flowering (took the minimum days to give flowers). The results presented the superiority in fruit number was achieved by the three Chinese varieties, and the Roumy cultivar. On the other hand no significant differences were found in okra fruit weights among all varieties, while, the maximum weight of fruits per plant was recorded in the Roumy and Yuncheng (Chinese 1) variety respectively. Chinese and Egyptian varieties of okra showed significant differences in chemical characteristics. The differences in the chemical characteristics significantly affected by the genotype and the environment and the interaction between them. Whereas the significantly ($P \leq 0.05$) highest total phenolic, flavonoid contents and antioxidant activity were recorded by Chinese 3 variety (The purple okra fruits), while Balady one registered the lowest value. No significant difference could be detected in the content of chlorophyll A and B among different varieties. Moreover, the data of the functional properties showed that okra gum of different varieties is acceptable and has good water-absorbing as additive in different food products.

Key words: Okra, Antioxidants, functional properties, Nutritional value.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an important annual summer vegetable crop that belongs to the Malvaceae Family. In most countries of the world, as well as Egypt, okra is consumed in immature pods (fresh, frozen, canned, and dry states). The pods are a nutritious and delicious vegetable, and fairly rich in many minerals and vitamins. One hundred fresh okra pods contains 8 g carbohydrates, 2.1 g protein, 1.7 g fiber, 0.2 g fat, 36 calories, 232.7 mg of vitamins, 1175.2 mg of minerals, and 88 g of water (Katung, 2007). The fresh immature pods are used as cooked or fried vegetables, the dried ones are particularly popular for adding to soups and stews and may be powdered for the application as a flavoring (Rajesh et al., 2018). Increasing production and improving quality is the primary interest of okra growers. In this connection, finding heavy-yielding varieties and their evaluation under local conditions are the common factors affecting okra production. Evaluation investigations of okra varieties were carried out by several authors (Khan et al., 2002; Rahman et al., 2012). Damarany & Farag (1994) and Helmy & Ragheb (2021) noted that, it is possible to increase the quality and yield of okra by means of introducing new varieties. In Egypt, there are many genotypes of okra scattered here and there in different parts of the country having diverse characteristics. Detailed studies of the physical and chemical characteristics of those genotypes are necessary to be known for the improvement of the yield and other desirable characters. Knowledge of the magnitudes of variation in the genotypes, the relation of properties with yield and the environmental effects on these materials are essential. Okra varieties may be classified on the basis of plant height, plant size, pod colour and pod shape. All the popular varieties have spineless pods in fresh form and the pod colour ranging from creamy white to dark green. It is usually cultivated from mid-March to the mid of April.

Some local okra varieties have been cultivated in Egypt for the last several decades. But these varieties didn’t give acceptable yields and are also affected by various diseases and different insect pests. So, there is an intensive need to introduce some new varieties with

DOI: 10.21608/asejaiqjsae.2022.281603

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Received November 25, 2022, Accepted, December 31, 2022.

higher yields and quality products. Jamala et al. (2011) reported the highest fresh pod yield of 10.7 tons ha^{-1} in the improved okra variety as compared to the local one that listed the lowest fresh pod yield of 4.9 tons ha-1. Khan et al. (2002) reported that the number of pods per plant and the weight of pods per plant significantly increased the yield of okra genotypes. Hussein et al. (2006) reported that variety Malav-27 gave the maximum number of selections (27.80), pods per plant (26.22), plant height (1.48m), pod diameter (1.46cm), yield hectare- 1 (14.57 tons) and took minimum days to feature (10.89). Sachan (2006) reported that Okra anamika is the most hopeful Okra variety. Sharma et al. (2011) recorded the highest pod weight (13.1g) and green pod yield (119.17 kg ha-1). Demrany and Faraq (1994) reported that Balady was the earliest flowering variety and produced the most pod/plant and the greatest total yield. Faisal et al. (2021) found that the number of leaves plant and plant height at maturity and the number of seeds / pod were significantly highest in V35 and Jokoso than in NH_4 okra variety. Some local varieties are cultivated in this area for the last several decades. But these varieties give no reasonable yields and are also influenced by different insects and diseases. Faisal et al. (2021) concluded that the variety 'Sabz Pari' showed the highest performance in all studded parameters followed by okra varieties Panjab selection, Anmol, and Sharmeeli. While the okra variety Anamika showed the least figure for pod yield. On the basis of present findings, it is recommended that the okra variety 'Sabz Pari' may be grown for achieving optimum results in climatic conditions of Sindh, Pakistan.

Epidemiological studies recommend that consuming foods that contain many bioactive compounds such as catechins in tea, anthocyanins in red, purple and blue vegetables and quercetin compounds may reduce the risk of diabetes, heart disease, hyperlipidemia, obesity, stroke and cancer. The main flavonoid content in okra (quercetin and isoquercetinand) was reported to have anti-diabetic activity *in vitro* studies. Okra has been reported to have many important biological properties and has been used extensively as traditional medicine, especially for diabetics (Xiao et al., 2011).

Faisal et al. (2021) reported the medical importance of the purple okra and reported that purple okra powder was superior to green okra powder in the improvement of diabetic markers in diabetic rats. Purple okra powder has even better potential than medications in implementing the improvement of fasting blood glucose insulin.

Anjani et al. (2018) reported that the antioxidant capacity, phenolic, and quercetin contents of purple okra extract were higher than green okra extract. There have been a lot of studies that demonstrated that purple okra contains higher quercetin than green okra. These results suggest that intervention of green okra extract, and purple okra extract based on quercetin compound showed a potency as anti-diabetic.

Okra contains bio-elements such as calcium, magnesium, potassium, sodium and iron and contains also vitamins which deficient in the diet of developing countries. It contains carbohydrates, proteins and fats. Okra is a good source of essential nutrients. It provides proteins, dietary fiber, carbohydrates, Proteins and iodine (Arapitsas, 2008).

Arapitsas (2008) found that one hundred grams of edible okra contain moisture (89.6 g), and minerals (0.7g): potassium 103 mg, phosphorus 56 mg, calcium 66 mg, sodium 6.9 mg, magnesium 53.0 mg. In addition it also contains protein (1.9g), where okra pods are known to be rich in high quality protein, especially with regards to its content of essential amino acids, carbohydrates (6.4g), fat (0.2g), fiber (1.2g), calories 35 calorie. Okra plays a particularly important role in human nutrition.

The present investigation aimed to compare Chinese and Egyptian varieties of okra in terms of productivity, chemical composition, nutritional value, functional properties, and antioxidant activity in the Egyptian Environment**.**

MATERIALS AND METHODS

The present study was carried out in the Vegetable Research Farm, Faculty of Agriculture, Alexandria University, Alexandria, Egypt, in the summer seasons of 2021 (June 2021). The soil of the experiment site was loamy clay.

The experiment included evaluation of five okra varieties which included three Chinese varieties that grown for the first time in Egypt, namely; Yuncheng (Chinese 1), Xingyun (Chinese 2) and Red Chien (Chinese 3) in addition to the local varieties Balady and Roumy which are very famous for the Egyptian farmers. The experiment was a randomized complete block design with three replicates. Each plot included three ridges (70 cm apart and 3.5 m long). Sowing seeds was done at 30 cm spacing on the northern side of the ridge.

In each plot, thinning was done 15 days after sowing, leaving the strongest and healthiest single plant/hill. All recommended agricultural practices for commercial okra production were followed. Immature (green) pods were picked at two days intervals. The following data were collected:

1- The height of plant (cm) was measured from the surface of soil to the bud in terminal of the main stem at the picking season end.

2- Earliness in flowering was measured as the number of days till 50% of flowering, i.e., when 50% of the plants were in the stage of blooming.

3-Average green fruit weight (g).

4- Green fruit numbers/plant, (total edible fruits that are picked per plant during the whole growing season).

5- Green fruits weight/plant (g).

6-Total yield of green fruits (ton/fed.), the weight of all edible fruits that were picked all over the growing season (Snedecor and Cochran, 1980).

Chemical methods

The gross chemical composition: moisture, protein, fat, ash, and fibers of okra fruits were evaluated as a standard procedure of AOAC (2012)

Mineral composition*:* Mineral element analysis was performed by dry ashing at 550 ºC. Minerals were extracted in (25 mL HCl 6N) and made up to 50 mL of distilled water. Different dilutions were prepared in order to determine elements (Na, and K) by Atomic Absorption Spectroscopy (AAS) with air/acetylene flame in a Perkin-Elmer 2280 spectrophotometer. For Ca and Mg quantify, a dilution with La_2O_3 (58.6 mg/L deionized water:HCl) was performed. Ca and Mg were determined using inductively coupled plasma atomic emission spectroscopy (ICP-OES).

Determination of carotenoids and chlorophyll:

A fine dried powder (150 mg) was energetically mixed with 10 mL of acetone–hexane solution (4:6) for 1 min and filtered through Whatman No. 4 filter paper. The absorbance of the filtrate was assessed spectrophotometrically (Agilent 8453UV-visible spectrophotometer, Canada) using preferred wavelengths 453, 505, 645, and 663 nm.

The content of β-carotene, lycopene, and chloropylls A and B were calculated according to the following equations:

β-carotene (mg/100 mL) = 0.216 ×A663 - 1.220 ×A645 - 0.304 × A505 + 0.452×A453;

lycopene (mg/100 mL) = -0.0458 × A663 + 0.204 ×A645 - 0.304 × A505 + 0.452 ×A453;

Chlorophyll A (mg/100 mL) = 0.999 ×A663 - 0.0989 ×A645;

Chlorophyll B (mg/100 mL) = -0.328×A663 + 1.77 ×A645, and further expressed in mg/100 g of fresh weight (AOAC, 2012).

Phenolic extraction: Ten grams of fruit powder of each variety was extracted for 24 hours by mixing with 100 mL of ethanol-water (50:50) at ambient temperature under magnetic stirring. The extracts were filtered, and the filtrate was concentrated by rotary vacuum evaporation at 40 ºC until obtaining a semi-solid residue.

Determination of total phenolic content

Total phenolic contents of okra methanolic extracts were determined using the method developed by Singleton et al. (1999). The determination was done in triplicate. The total phenol content (TPC) was calculated as Gallic acid equivalent in mg/100 g sample.

Determination of total flavonoids

Total flavonoids content of okra extracts were determined according to Barros et al. (2013). A calibration curve of rutin was prepared and total flavonoids content was determined.

Determination of antioxidant activity of okra sample fruits.

1- DPPH scavenging activity %

The scavenging activity of the stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical was determined according to a procedure based on Brand-Williams et al. (1995); Miliauskas et al. (2004) and it's modifications by Lim and Quah (2007). Triplicates were prepared for each extract. The results were expressed as % radical scavenging activity.

$$Radical\ scavenging\ activity\% = \frac{(A\ control - A\ sample)}{Acontrol} x100$$

2- Ferric reducing antioxidant power (FRAP)

This method was suggested by Pulido et al. (2000) which involves the presence of antioxidants in the extract to reduce the ferricyanide complex to the ferrous form. The determination of FRAP values was done in triplicate for each extract. The FRAP values were calculated in mg Gallic Acid Equivalent (GAE/g), and were derived from a standard curve.

Extraction of gum from okra fruits

Okra gum was extracted from okra fruits. The fruits were cleaned, washed, sliced, crushed and then macerated in distilled water for 10 hours with intermittent stirring. The mucilage was filtered through a white muslin cloth to extract the gum and acetone was added to separate the extracted gum. The gum was filtered under a vacuum to remove acetone then dried and kept in airtight jars till used.

Functional properties of okra mucilage:

1- Water Absorption Capacity

The water absorption capacity (WAC) of the okra mucilage was determined as described by Mishra and Rai (2006) in triplicate using 2.5% okra mucilage suspensions at a temperature of 25 °C. Dried okra samples (0.125 g) were weighed into pre-weighed centrifuge tubes and 5 mL of distilled water was added. The samples were heated at the above temperature for 1 h with constant shaking and thereafter centrifuged for 15 min at 1500 × g. The free water was poured and the tubes were allowed to drain for 10 min at a 45° angle. Subsequently, the sample tubes were weighed, and the gain in weight was used to calculate the water absorption capacity.

WAC = (W3 – W2) /W1 where,

W1= the weight of sample

W2= the weight of empty centrifuge tube

W3= the weight of the tube after centrifugation and decanting

2- Oil Absorption Capacity:

Okra mucilage (2.5 g dry weight basis) was mixed with 20 ml oil in a pre-weighted centrifuge tube and then stirred for 2 min on a vortex mixer and allowed to stand for 30 min at 25°C, centrifuged at 3000 × g for 10 min at 10 °C (Eppendorf 5810 R, Germany) and the supernatant was poured. The obtained weight was expressed as oil absorption capacity (Mir et al., 2017).

WAC = (W3 – W2) /W1

W1= the weight of a sample

W2= the weight of the empty centrifuge tube

W3=the weight of the tube after centrifugation and decanting.

Sensory evaluation

Sensory evaluation of blanched okra samples was done for appraising the sensory traits of the product. It was carried out by a panel consisting of 10 trained panels including staff members, assistants, and engineers from the faculty of agriculture, Alexandria University, Food Science and Technology Department using a preference test with a 9-point hedonic scale (1=dislike extremely, 9= like extremely) to determine color, springiness, toughness and overall liking of products (Bordi et al., 2013).

Statistical analysis

Each analysis was done at least in triplicate and the results are expressed as mean and standard deviation (SD). Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $P \geq 0.05$ being considered statistically significant using the SAS software program (SAS, 2004).

RESULT AND DISCUSSION

Plant height (cm)

Results of the plant height (cm) illustrated in Fig (1) clarified significant variations for all the varieties of okra. The maximum height (154.9) was recorded in the Balady local variety which exceeded the rest of the varieties followed significantly by Romy and the Chinese variety Yuncheng. However, the two Chinese varieties Xiengyun and Red Chien gave significantly ($P \leq 0.05$) the lowest heights.

Shalan et al. (2011) reported that the Al-Hemaa okra variety was characterized by the longest plant height, while the genotype Manshaa possessed the shortest height. Khan et al. (2002) observed that Clemson is one of the good height-producing varieties of okra. But the local variety was also highly competitive with the aforementioned two varieties. The results of these three varieties were statistically at par with each other and also remained non-significant among each other. Pusa sawani was a short height variety. It might attribute to its varietal nature. These results agree with the findings of Demrany and Faraq (1994) who stated that the Balady variety gave a greater plant height and number of branches per plant than Blondy. Feisal et al. (2021) indicated that the okra variety 'Sabz Pari' upshot the greatest plant height as compared to the other okra varieties.

Days taken to flowering

The data in Fig (1) pertaining to the number of days taken to flowering showed a significant ($P \leq 0.05$) behavior. A maximum number of days (92.33) to flowering was taken by the Balady variety followed by the Chinese variety Xingyun with 60 days, Whereas, both the local variety Romy and the Chinese variety Yungcheng took 41.2 and 42.33 days to give the flowers which reflect the earliness of these two varieties. These results are in agreement with that of Attalah (2017) who stated that the Pusasawani okra variety took the maximum number of days to flowering however; the Emeral and okra variety was the earliest. Moreover Shalan et al. (2011) stated that Al-Sabahia and Ityei El-Barudb genotypes were the earliest ones, on contrary to Al-Hemaa okra variety being the latest.

Average fruit weight:

The economical part of the okra crop is its fruits. Okra fruits are used as fresh vegetables and used in our daily diet. Data in Fig (1) show that maximum fruit weight (7.5 g) was achieved by the Balady variety; the results for okra fruit weight remained non-significant for the rest of the varieties.

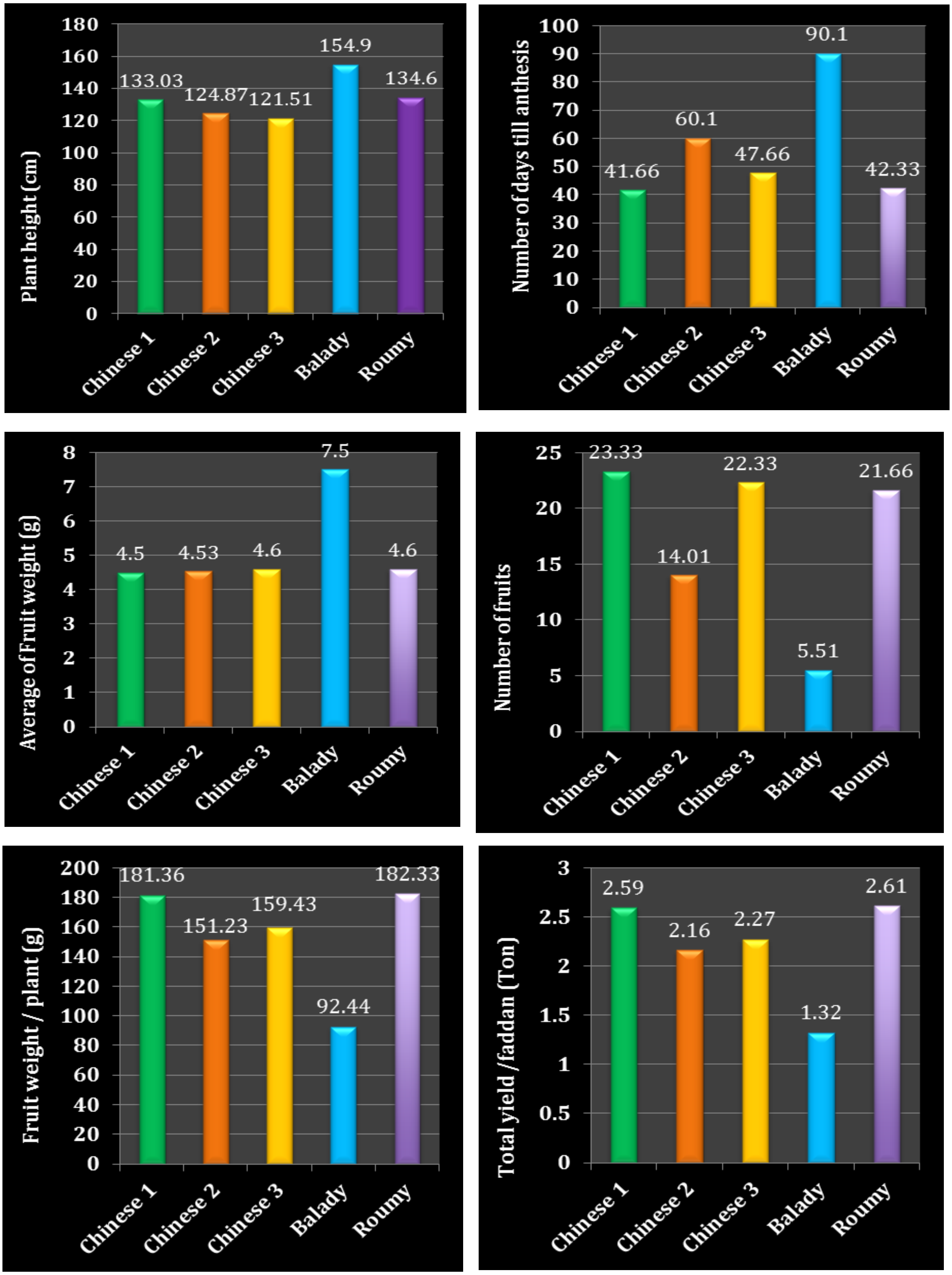

Fig. 1. Plant height, Number of days till flowering, Average of fruit weight, Number of fruits, Fruit weight/ plant, Total yield/ faddan for different okra varieties

These results coincide with the findings of Faisal et al. (2021) who stated that the okra variety 'Sabz Pari' possessed significantly ($P \leq 0.05$) maximum fruit length as compared to the rest of the okra varieties Shalan et al. (2011) reported that the longest fruit resulted from A-Sabahia, Damanhur, Ityei El-Barud and Aswan genotypes while the shortest one was obtained from Al-Hemaa, Al-Sheikh Makram, Manshaa, Red and Tanta genotypes in Egypt.

The Number of fruits per plant

The results in Fig (1) show the superiority in fruit number for the three varieties, Yuncheng, Red Chinese, and Roumy with non-significant differences with a total number of fruits 23.33, 22.33, and 21.66, respectively. However, the minimum fruits per plant were recorded as 5.51 from the plots where Balady variety and it was followed by Xingyun, which gave 14.01 fruits per plant. Probably it might be due to their natural characteristic, or it might attribute to the non-adaptation to the climatic and soil conditions of the area. These findings are in agreement with the results obtained by Elhag and Ahmed (2014) who also stated that the Pusasawani variety had the lowest number of fruits per plant. Rahman et al. (2012) also reported that the number of fruits per plant had a non-significant effect on different varieties of okra. Atallah (2017) reported that the okra variety **'**Emerald' produced significantly ($P \leq 0.05$) greater values for fruits per plant (36.33) as compared to the rest of okra genotypes

Weight of fruits per plant (g)

Statistical analysis of the data revealed significant differences ($P \leq 0.05$) among the various means of the okra variety. The maximum weight of fruits per plant (182.33 and 181.36 g) was recorded in the Roumy and Yuncheng varieties, respectively, without significant difference ($P \leq 0.05$) followed by Red Chine and Xingyun varieties with the fruit weight of 159.43 and 151.23 g, respectively. Whereas, the minimum fruit weight was noted as 92.44 g, in the local Balady okra variety, Fig (1). The results are supported by those the findings of Rajesh et al. (2018) who reported that a maximum fruit weight of 742.32 g was recorded in the Clemson okra variety.

Yield of fruits (t ha^{-1})

The analysis of the treatment means revealed significant differences for different okra varieties. Fresh fruits are the economic portion of the okra. Different varieties clarified almost similar trends as it was in the case of fruits' weight. Results in Fig (1) indicated that maximum yield (2.61 and 2.59 ton fadan^{-1}) was recorded for the two varieties Roumy and Yuncheng. The minimum fruits yield was noted as 1.32 ton fadan^{-1}, from the local Balady okra variety. The results coincide with the findings of Hussain et al. (2006) who stated that Pusa green variety is one of the leading varieties of okra producing high yields of fruits. Khan et al. (2002) recorded the same results that Pusa green is the highest yield producing okra variety, closely followed and at par with Clemson and Penta green varieties. Damarany and Farag (1994) observed that the "Blondy" variety recorded a higher number of fruits/plant, a yield of small fruits, large fruits and total fruits yield compared to the Balady variety. However, Balady gave the greater plant height and a number of branches per plant than Jamala et al. (2011), and Katung (2007) and others reported considerable variation among okra varieties.

Chemical composition

Okra varieties investigated here differ significantly in chemical composition, due to genotype and environment and the interaction between them.

The highest moisture content was recorded for Balady one. Moreover, there were no significant differences in the moisture content for the new 1, 2 and Turkey okra. Haj Romdhane et al. (2020) reported that the moisture content of the Tunisian okra is 81.9 %.

Hassan and Ali (2015) studied the chemical composition of three varieties of Egyptian Balady okra seeds flour and reported significant ($p \leq 0.05$) moisture content (1.23-10.54%). The results in Table (1) did not show a great significant difference among the five tested okra varieties in both protein and fat content.

As dietary fiber intake is associated with several health interests, the European Food Safety Authority referenced a dietary fiber intake of 25 g per day in adults. The dietary fiber content of the different investigated okra samples differ significantly and ranged from 7.55 to 8.33 g/100g fresh weight. Higher content of dietary fiber was noticed for the new Chinese varieties.

These results are similar to those found by Haj Romdhane et al. (2020) who found that the total dietary fiber content of the analyzed Tunisian okra fruits was 8.16 g 100 g/ fresh weight. The chemical composition of the different investigated okra varieties is presented in Table (1).

The mineral composition of different okra fruits is shown in Table 1. The main mineral found in the analyzed samples of the Chinese 1 variety was potassium (337 mg/100 g fresh weight) followed by calcium (266 mg/100 g fresh w), sodium (130 mg/100 g fresh weight), and finally magnesium (102.12 mg/100g fresh weight). This tendency and similar values were previously registered by other authors for different okra genotypes. According to previous studies both macro and micro elements are considered to be essential to human nutrition, so, okra is an interesting food due to its mineral composition.

Phenolic content and bioactive Proprieties.

Table 2 shows the total phenolic contents (TPC) and antioxidant properties of the five varieties of okra used in the study. The highest (TPC) (571.04±0.34 mg/100g), was recorded by the Chinese 3 variety (the purple okra fruits) while Balady one registered the lowest FC of 513.07±1 mg/100g in the extract. The highest flavonoid content (FC) was recorded also for the Chinese 3 varieties (24.22±0.82mg/100g) while Balady and Roumy had the lowest FC without a significant difference between them.

The values of the total phenolic content obtained in the present study are lower than the results of Hassan and Ali (2015) who reported that the phenolic content of different Egyptian okra varieties ranged from 802.20 to 789.59mg GAE/100 g on dry weight and higher flavonoids content ranged from 11.80 to 15.14mg/100g dry weight was traced for the same Egyptian varieties.

DPPH (2,2-diphenyl-1-picrylhydrazyl) is a relatively stable free radical; antioxidants are used to reduce free radicals by providing hydrogen atoms or electrons. Therefore, the DPPH radical is a molecule used to evaluate the free radical scavenging activity. DPPH assay was determined and the results were observed and are shown in Table (2). The results reveal that the local okra varieties showed fewer results contrary to the Chinese new varieties.

The FRAP (ferric reducing antioxidant power) assay takes advantage of the electron-transfer reaction. The transfer of the electron from the antioxidant to the probe resembles the redox titration in classical chemical analysis because there is not a competitive reaction involved and there is no oxygen radical in the assay.

The higher reducing power of the methanolic extract might be attributed to the greater hydrogen donating capability shown for the Chinese 3 variety as presented in Table (2).

The high antioxidant activity of three new Chinese varieties may be attributed to the high content of both the total phenolic and flavonoids of okra. Phenolic acids and flavonoids have been reported to be the main phytochemicals responsible for the antioxidant capacity of fruits and vegetables.

Colour and pigments content

Chlorophyll (A and B) and carotenoids (β- carotene) are common organic food components giving a specific coloration to plants since they are naturally present in them. Chlorophyll, although not principally significant nutritionally, offered a measure of green vegetable color, an estimation of senescence for consumers.

All three pigments are sensitive to various intrinsic and extrinsic factors including temperature, pH, light, oxygen, metal ions and enzymes so this may be the cause of the unstable purple color for the Chinese 3 (purple) okra variety. Oxygen permeating through the packaging bags also can affect the stability of natural color pigments as they are sensitive to molecular oxygen due to their unsaturated structure.

Table 1. The proximate composition and mineral content (mg /100 g fresh weight) of the studied okra fruits of the different investigated okra varieties.

Component %	Balady	Chinese 1	Chinese 2	Chinese 3	Roumy
NFE*	2.87±0.16^{bc}	3.76±0.34^{a}	2.48±0.38^{c}	2.95±0.12^{bc}	3.62±0.24^{ab}
Un-soluble fibers	4.52±0.16^{ab}	4.29±0.10^{b}	4.68±0.09^{a}	4.37±0.04^{b}	4.32±0.100^{b}
Soluble fibers	3.39±0.06^{c}	3.26±0.13^{c}	3.65±0.08^{b}	3.94±0.07^{a}	3.32±0.100^{c}
Fat	0.07±0.005^{a}	0.07±0.05^{a}	0.06±0.05^{ab}	0.05±0.05^{b}	0.06±0.005^{ab}
Protein	3.39±0.06^{b}	3.26±0.132^{b}	3.65±0.07^{a}	3.36±0.04^{b}	3.32±0.100^{b}
Ash	1.28±0.01^{c}	1.27±0.011^{c}	1.32±0.05^{a}	1.29±0.01b^{c}	1.31±0.011^{ab}
Moisture	84.45±0.22^{a}	84.07±0.6^{b}	84.13±0.14^{ab}	84.02±0.02^{b}	84.03±0.05^{b}
Minerals content (mg/ 100g)					
Calcium	266	254	255	254	266
Potassium	337	331	330	350	327
Sodium	127	130	127	121	121
Magnesium	102	102.12	102.14	101.15	101

Different letters in rows indicate significantly different values at (P ≤ 0.05). Values are mean ± SD (n = 3). NFE* means nitrogen free extract or available carbohydrates calculated by difference.

Table 2. Phenolic content, flavonoids and anti-oxidant activity properties of the different investigated okra varieties.

Property	Balady	Chinese 1	Chinese 2	Chinese 3	Roumy
DPPH(% inhibition)	30.21±0.01^{d}	31.50±0.11 ^{c}	31.93±0.35 ^{b}	35.01±0.01^{a}	30.25±0.14^{d}
FRAP(µ mol/L)	5.20±0.053^{d}	6.18±0.04 ^{c}	6.67±0.02^{b}	7.14±0.05^{a}	5.27±0.05^{d}
Total phenolic (mg GAE/100g)	513.07±1.00^{e}	562±3.37 ^{c}	567.74±2.20^{b}	571.04±0.30^{a}	345.79±0.21^{d}
Flavanoids (mg RE/100g)	15.6±0.23 ^{d}	16.31±0.19 ^{c}	20.27±0.16^{b}	24.22±0. 83^{a}	15.55±0.41^{d}

Means with same letters in a row are not statistically different (P≤0.05) from each other according to Duncan's multiple range tests. All values are mean ± standard deviation of three replicates (n=10). GAE: Gallic Acid Equivalent, RE: Rutin Equivalent.

Highly significant differences for all the characters indicated great differences in all the characters studied which may be attributed to differences in the genetic component of the various genotypes.

Results in Table (3) show chlorophyll A, B and β-carotene content of different varieties of okra. The result shows that, there is no great significant difference among different varieties in both chlorophyll A and B. The local varieties namely; Balady and Roumy contain higher chlorophyll A content than the new ones. No significant difference was noted between varieties for chlorophyll B content except the Chinese 3 variety, which contained fewer amounts.

Significant variations in the amount of β -carotene were found when considering different genotype effects. It varied from 0.82 to 0.88 mg/100g. Chinese 3 variety had the maximum amount of β-carotene, while the minimum amount of β-carotene was found in Balady okra.

Functional properties of okra mucilage

Carbohydrates are mainly present in okra fruits in the form of mucilage. That young fruit consists of long chain molecules with a molecular weight of about 170,000 made up of sugar units, and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%). The mucilage is highly soluble in water. Its solution in water has an intrinsic viscosity value of about 30%. Liu et al. (2005). "Okra" mucilage has the potential for use as food, non-food products, and medicine.

The results of the water and oil absorption capacity of the okra mucilage are presented in table 4. The okra mucilage showed a water absorption capacity (WAC) value of 3.57 g water/g dry sample and an oil absorption capacity of 1.50 g oil/g dry sample weight of mucilage. The results indicated that okra mucilage clarified a higher value of water absorption capacity compared to the oil absorption capacity.

Sensory evaluation of okra samples

The sensory quality of blanched okra samples is presented in Table 5. No great significant difference was noticed between different okra varieties. All tested okra samples were highly acceptable. It is worth pointing out that all the parameters analyzed obtained overall acceptability from 8.6 to 9 according to the hedonic scale compared to 8.2 for the Balady variety.

Table 3. Pigments (mg/ 100g fresh weight) content of the different investigated okra varieties.

Pigment	Balady	Chinese 1	Chinese 2	Chinese 3	Roumy
Chlorophyll a	3.78±0.01^{a}	3.47±0.037^{b}	3.47±0.06^{b}	3.25±0.03^{c}	3.74±0.05^{a}
Chlorophyll b	2.86±0.01^{a}	263±0.15^{a}	2.73±0.23^{a}	2.25±0.14^{b}	2.87±0.05^{a}
β-Carotene	0.82±0.11^{c}	0.85±0.011^{b}	0.87±0.05^{a}	0.88±0.05^{a}	0.83±0.05^{bc}

Means with same letters in a row are not statistically different (P≤0.05) from each other according to Duncan's multiple range tests.

Table 4. Some functional properties of the different investigated okra varieties mucilage.

Property	Balady	Chinese 1	Chinese 2	Chinese 3	Roumy
Oil absorption (g oil/ g dry sample)	1.50±0.05^{a}	1.40±0.08^{ab}	1.44±0.09^{ab}	1.36±0.04^{b}	1.47±0.051^{ab}
Water absorption (g water / g dry sample)	3.12±0.11^{b}	3.23±0.20^{ab}	3.57±0.115^{a}	3.22±0.22^{b}	3.27±0.23^{ab}

Means with the same letters in a row are not statistically different (P≤0.05) from each other according to Duncan's multiple range tests.

Table 5. Sensory properties of the different investigated okra varieties.

Sensory property	Balady	Chinese 1	Chinese 2	Chinese 3	Roumy
Over all acceptability	8.2 [ab]	8.6 [a]	8.8 [a]	8.6 [a]	9 [a]
Odour	8.6 [a]	8.6 [a]	8.6 [a]	8.6 [a]	8.8 [a]
Texture	7 [b]	8 [a]	8 [a]	8 [a]	8 [a]
Colour	8 [a]	8 [a]	8 [a]	8 [a]	8 [a]
Taste	7.4 [b]	8.4 [ab]	8.4 [ab]	7.6 [b]	0 [a]

Means with the same letters in a row are not statistically different ($P \leq 0.05$) from each other according to Duncan's multiple range tests.

CONCLUSION

New Chinese okra possesses high amounts of total flavonoids as well as moderate amounts of total phenolic content, making it a good source of natural antioxidants. There is significant variability among the five varieties with respect to FCs, TPCs, and total antioxidant activity. The antioxidant assays indicate that the okra fruit is a good source of phytochemicals. Thus based on the antioxidant activity, okra fruit extracts of different varieties should be considered as an additive to other products for oxidative protection. All the antioxidant assays in methanol indicated that the new Chinese okra fruits showed higher DPPH scavenging activity, Ferric reducing antioxidant power (FRAP), and total phenolic content compared to the local ones (Balady and Roumy). The results of the functional properties showed that okra gum is acceptable and good water-absorbing additive in different food products.

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الملخص العربي

تقييم ثلاثة أصناف صينية من الباميه (*Abelmoschus esculentus* L) زرعت في مصر

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هدفت هذه الدراسة إلى معرفة إمكانية زراعة أصناف البامية الصينية الجديدة عالية الإنتاجية Yuncheng(الصينية ١) و Xingyun (الصينية ٢) و Red Chien (الصينية ٣) في مصر ومقارنة خصائصها (التركيب الكيميائي، الخصائص الوظيفية، النشاط المضاد للأكسدة، والخصائص الحسية) بخصائص أصناف البامية المصرية (بلدي ورومي). أظهرت النتائج أن كل اصناف البامية اختلف معنويا في صفات ارتفاع النبات. كما أظهرت النتائج أن الصنف البلدي تأخر في التزهير (استغرقت الأيام القصوى لإعطاء الأزهار) متبوعًا بالصنف الصيني Xingyun، بينما كان الصنف Roumy والصنف الصيني ١ مبكرًا في التزهير (استغرق أقل عدد أيام لإعطاء الأزهار). أظهرت النتائج إرتفاع في عدد الثمار الذي تحقق من خلال الأصناف الصينية الثلاثة، وصنف رومي. من ناحية أخرى لم توجد فروق ذات دلالة إحصائية في أوزان ثمار البامية بين جميع الأصناف، بينما سجل أقصى وزن للثمرة لكل نبات في صنف رومي و Yuncheng(صيني ١) على الترتيب.كما أظهرت أصناف البامية الصينية والمصرية اختلافات معنوية في الخصائص الكيميائية. تأثرت الفروق في الخواص الكيميائية معنويا بالنمط الوراثي والبيئة والتفاعل بينهما، بينما سجل الصنف الصيني الثالث (ثمار البامية الأرجوانية) أعلى نسبة من المواد الفينولية والفلافونويد ونشاط مضاد للأكسدة، بينما سجل النوع البلدي أدنى مستوى. لتلك الخصائص.كما لوحظ انه لا يوجد فرق كبير في محتوى الكلوروفيل A وB بين الأصناف المختلفة. علاوة على ذلك، أظهرت البيانات الخاصة بالخصائص الوظيفية أن صمغ البامية من الأصناف المختلفة مقبول واعتباره مضاف جيد لامتصاص الماء في المنتجات الغذائية المختلفة.