PERFORMANCE OF NEW IMPORTED FOREIGN GARLIC GENOTYPES GROWN UNDER THE EGYPTIAN CONDITIONS

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Abstract

Evaluating some new imported and locally cultivated garlic (*Allium sativum* L.) genotypes under the Egyptian conditions resulted in promising results which showed significant differences among the tested genotypes. Although some of the foreign cultivars seemed to be promising genotypes the Egyptian cultivars and clones showed most of the desirable horticultural characteristics (as they are adapted to the Egyptian conditions) such as germinating faster with the germination percentage (92.11%) and the highest plants value (99.70 cm) both were recorded for "Clone 24", the highest value of bulb weight (172.59 g) for "Sids 40", the highest yield (10.70 ton/fed.) for "Sids 40", the highest protein content (10.24%) for "Balady", and highest carbohydrates (nitrogen-free extract) content (30.11%) for "Egaseed 1". On the other hand, the imported cultivars showed the lowest value of No. of cloves/bulb (6.10) for "Inchelium Red" as a desirable quality characteristic, the highest moisture content (71.77%) for "White Brazilian", the highest value of crude lipids content (0.973%) for "California Late", the highest value of ash content (3.73%) for "California Early", and the highest fiber content (1.037%) for "White Brazilian". The nitrate concentration (NO_3^{1-} mg/kg) determined in garlic extracts ranged from 25.1 to 44.6. The highest level (44.6 mg/kg) of nitrates was recorded in extracts of "California Early". Nitrite (NO_2^{1-}) concentrations ranged from 0.39 to 1.7 mg/ion kg and the cultivar "Lorz Italian" contained the highest level. L-Ascorbic acid (L-AA) or Vitamin C concentrations ranged from 3.63 to 7.55 (mg/100g) and the highest level recorded in tissues of "Clone 24". The highest levels of TPCs (Total phenolic compounds) were recorded in the HCl-methanolic extracts to be 18.6 and 18 mg/100g for "California Early" and "California Late" cultivars, respectively, Total flavonoids content was assayed and the results showed that the "Clone 24" had the highest level (10.9 µg/g) of flavonoids. This work was done to select the best of the new imported garlic cultivars which will meet the Egyptian growing conditions and decide which is good for local and foreign markets and which is good for industrial purposes.

Key Words: Allium sativum, Garlic, Genotypes, Introduction, Evaluation, Total flavonoids, garlic phenolics, Nitrites and Nitrates in garlic.

INTRODUCTION

Allium sativum is a diploid species (2n = 2X = 16), belongs to the *Alliaceae* family whose cultivation history dates back 3000 years B.C. (Figliuolo *et al.*, 2001). It is generally not fertile and is thus asexually propagated by cloves. The origin of garlic is considered to be Central Asia from where it has spread to the west, south and east of Asia (Etoh *et al.*, 2001). Garlic is a sterile species whose variability in morphological and physiological characteristics is desirable. The vegetative mode of multiplication of the species only allows clonal selection methods. Clonal selection is a major breeding method for garlic, since plant sterility precludes crop improvement by means of cross hybridization. Since no segregating population is available, stability and inheritance of specific traits obtained through clonal selection is hard to be monitored by normal genetic analysis (Lampasonal *et al.*, 2003). A solution is sought in the use of domestic ecotypes, which are fully adapted to local conditions and are important genetic resources and initial clonal selection materials (Gvozdanovic-Vagar *et al.*, 2002). A wide range of adaptability to soil types, temperatures and day length, makes its farming possible from tropics to temperate latitudes. A better knowledge of the genetic variation for vegetative yield-related traits and phytochemical potential of this species is precious for an economic use of genes and genomes.

For many centuries, various species of the genus *Allium* have been used as vegetables, spices and as folk medicines. Garlic is a common food spice, and is used widely in many parts of the world as a condiment in various prepared food such as mayonnaise, tomato sauce, salad dressing, meat sausage, pastrima and pickled products (Ahmed *et al.*, 2001) and is also cultivated for its medicinal properties and this aspect is steadily on the rise worldwide. It lowers total plasma cholesterol, reduces blood pressure and decreases platelet aggregation (Sterling and Eagling, 2001). Most of the medicinal effects of garlic are attributable to a sulfur compound known as allicin (Schulz *et al.*, 1998). Furthermore, genetic factors can play an important role in differences of allicin content between ecotypes (Baghalian *et al.*, 2005). Clonal selection of garlic with suitable content of allicin and agronomical traits is desirable for large-scale culture and drug production.

In this work, we evaluated the horticultural characteristics, biochemical and feeding prosperities of some new-imported garlic cultivars through some light upon which will behave well and adapt with the Middle Egypt growing conditions similar to what was done with the Chinese garlic cultivars which are broadly grown in Egypt nowadays. Furthermore, the behavior of these genotypes was compared with some Egyptian and/or Chinese locally cultivated garlic cultivars and clones.

MATERIALS AND METHODS

Garlic new-imported and local garlic genotypes

Six foreign genotypes (White Brazilian "clone", Inchelium Red, California Early, California Late, Early Red Italian, and Lorz Italian "varieties") were imported to Egypt from Brazil by Dr. Gad El-Hak, Minia University the United States of America by MUCIA (Midwest Universities Consortium for International Activities). These entries were classified to the Artichoke garlic group, which belongs to *Allium sativum* subsp. Sativum. Also, three Egyptian and/or Chinese types {Balady (Egyptian wide spread cultivar), Sids 40 and Egaseed1 varieties} along with two clones {Clone 24 and Clone 21(selected from a Chinese cultivar by Sids Research Station, Agricultural Research Institute, Giza, Egypt)} which are adapted to grow under the Egyptian conditions were evaluated to be compared with the imported varieties. The aforementioned imported garlic cultivars and three other cultivars {Mild French, Silver White (both belong to the Silver Skin garlic group) and Asian Tempest (belongs to the Asiatic garlic group)} from Filaree Farm (USA) along with the Balady and Sids 40 cultivars were first planted and evaluated in four locations, two in Minia governorate (Minia University and Kaissy farms) and two in Beni Suef governorate (Sids station and Yassin farms) in the first week of October of the winter season (2006/2007 year). The growing behavior of these different varieties were assayed in the cultivations of the four locations as shown in Tables (1, 2 and 3), however, the bulb characteristics for those genotypes are shown only of Minia University location (Table 3). Bulbs were collected from all the genotypes except for (Mild French, Asian Tempest, and Silver White) cultivars which didn't give any true bulbs.

All these garlic genotypes (Imported and Egyptian locally cultivated) were planted in the farm of the faculty of Agriculture, Minia University, Egypt in the 18th of October, 2007 to evaluate the behavior of the new imported genotypes under the Middle Egypt (Minia governorate) conditions and select the promising ones. Photos of bulbs of the foreign genotypes when they were imported and before cultivation in Egypt are shown in Plate 1 and their photos after planting in the first and second seasons are shown in Plate 2.

Experimental design

The above mentioned genotypes were planted in similar plots of 3x3.5 m in a replicated Randomized Complete Block Design (RCBD). Three plots were used as replicates for every genotype and the replicates were random distributed in the field. Planting was done in single rows on 70 cm wide bed and cloves were hand planted approximately 10 cm apart in the row.

Horticultural Practices

1. Pre-planting treatment

Bulbs were carefully separated into individual cloves. Then, the cloves were soaked 24 h in tap water, then were soaked in aqueous sulfur solution for 20 minutes before planting. The principal target of water and sulfur dipping was to enhance sprouting and to control pests if present on the clove surfaces.

2. Fertilization

Manure fertilizer (30 m^3) was applied to the soil while preparation and before garlic plantation and the NPK chemical fertilizer recommended for garlic cultivation were applied {110 kg N (ammonium sulphate), 62 kg P_2O_5 (super phosphate) and 96 kg K_2O (potassium chloride)}.

Irrigation and weed control

The plants were irrigated according to plant needs and weeds were controlled by tilling and/or hand weeding.

3. Recorded data

The recorded data describing the horticultural behavior of the imported and locally cultivated genotypes are as follow:

1. Percentage of germination after 10, 20, and 30 days from planting.
2. Plant height (cm) at harvest time.
3. Number of cloves/ bulb at harvest time.
4. Bulb fresh weight (g) at harvest time.
5. Fresh yield as kg/plot and ton/fed.
6. Neck and Bulb diameter (cm) at different times of plant growth stages.
7. Bulbing ratio (neck diameter/ bulb diameter) calculated by Mann, 1952.

Statistical analysis

All obtained data were subjected to statistical analysis of variance and the least significant difference (L.S.D.) at 5% and 1% levels of probability were calculated as mentioned by Gomez and Gomez, 1984.

I. Chemical determinations

1. Sample preparation

Garlic bulbs stored at room temperature (26±3°C) were subjected to mild pressure by hand to separate into cloves. Peeling was done manually, garlic bulbs were separated into the individual sound cloves, the cloves were then carefully peeled with a stainless steel knife and then were cut in half. Garlic bulbs were crushed in a blender (Moulinex HVS, Model A14, Moulinex, France) until a smooth puree was obtained (3 min). The garlic puree was packaged in polyethylene bags. The samples were stored at a freezer until chemical analyses.

2. Chemical properties

Total soluble solids of the garlic samples were immediately measured on arrival samples from the Vegetables Farm of the Faculty of Agriculture, Minia University. The crude protein was determined using the Macro Kjeldahl method (AOAC, 2000) and the ether-extractable lipid of garlic was determined with the Soxhlet extraction procedure (AOAC, 2000). The ash content was determined according to (AOAC, 2000) method 925.51 and crude fibers were determined according to Weende, (AOAC, 2000) 920.169 methods, based on the solublization of non cellulosic compounds by sulfuric acid and sodium hydroxide solution. Nitrogen-free extract was obtained in a usual manner by calculation.

3. Determination of nitrite (NO2-1) and nitrate (NO3-1)

The NO_2^{-1} and NO_3^{-1} were extracted from garlic cloves by 1% K_2SO_4 solution and determined spectrophotometrically as described by Saad (1991).

4. Determination of L-Ascorbic acid (L-AA)

The indophenol method (2,6-dichlorophenol indophenol, 50 mg in 250 ml H_2O) as described by Mondy and Ponnampalam (1986) was used for the determination of ascorbic acid concentration in garlic cloves.

5. Extraction and determination of the total phenolic compounds (TPCs)

TPCs content was extracted from each defatted sample (0.5g) with MeOH-HCl (1:10) and determined according to the method as described by Taga *et al.* (1984).

6. Extraction and Determination of total flavonoids (TFs)

Defatted meal garlic tissues (3.0 g) were extracted in a Soxhlet extractor with 100 ml ethanol for 1 hour and the extract was filtered and TFs content was determined according to the method described by Zhuang *et al.* (1992).

RESULTS AND DISCUSSION

1. Horticultural characteristics

Growing behavior of the studied imported genotypes did not vary much when we compared the plantations in the four locations as described in the Materials and Methods section although the genotypes sometimes varied between the two locations in the same governorate especially in the germinations percentage characteristic (Table 1, 2 and 3). Moreover, the different tested genotypes varied significantly in most of the studied characteristics when their average of the four locations was compared. On the other hand, the quality of their bulbs produced from the first evaluation season was not good in shape and size comparing to the good quality of their bulbs when they were received from the MUCIA office (Plate 1 and 2). However, improved bulb quality of these genotypes was obtained from the second planting season (Plate 2).

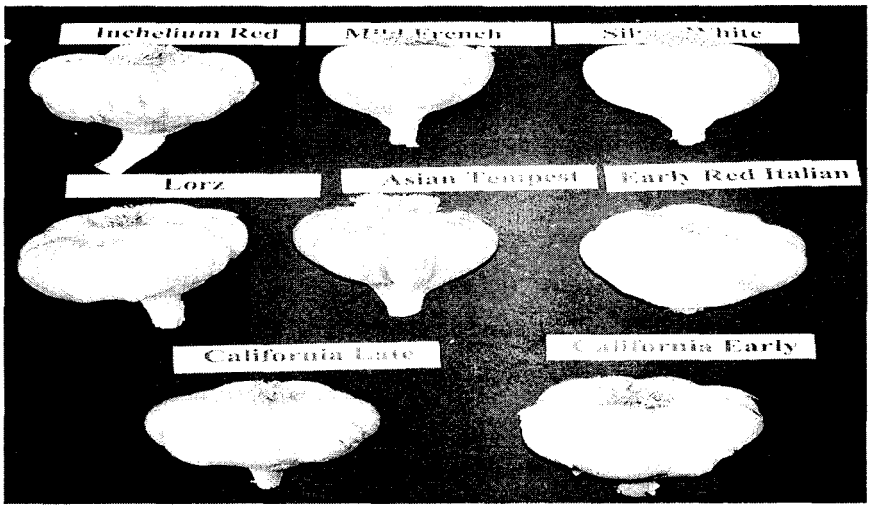

Plate 1. Photos of bulbs of the imported garlic cultivars before planting in Egypt.

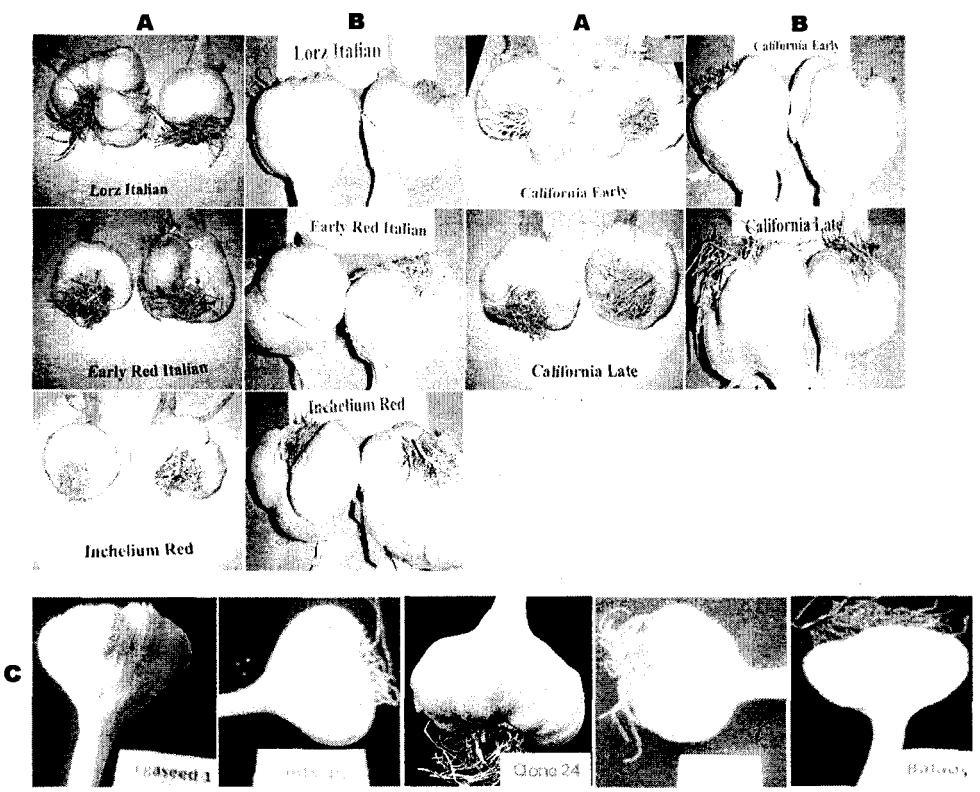

Plate 2. Photos of the imported garlic cultivars after planting in Egypt. A) Photos of bulbs harvested from the first planting season (up), B) Photos of bulbs harvested from the second planting season (down). Notice, the quality of bulbs is much better in the second season comparing to the first one. C) Photos of bulbs of the Egyptian locally cultivated garlic cultivars and clones (Egaseed 1, Sids 40 and Clone 21 are originated from the Chinese cultivars grown in Egypt by selection and Clone 24 is originated from the Egyptian Balady cultivar).

Table 1. Percentage of clove-seed germination after 15 and 30 days from planting of the imported and locally cultivated garlic cultivars grown at four locations under Minia and Beni Suef governorates planting conditions in winter season of 2006/2007 year.

Percentage of clove-seed germination											
Entry	Code No.	After 15 days from planting				Mean of entries (B)	After 30 days from planting				Mean of entries (B)
		Minia Governorate		Beni Suef Governorate			Minia Governorate		Beni Suef Governorate		
		Minia Univ. farm	Kaissy farm	Sids station	Yassin farm		Minia Univ. farm	Kaissy farm	Sids station	Yassin farm	
California Early	6	9.6	16.6	15	10.0	12.80	38.7	76.6	60.0	65.5	63.20
California Late	7	7.1	13.8	10	5.0	8.97	21.4	26.6	10.0	31.7	22.43
Lorz Italian	8	3.4	22.2	30	0.0	13.90	20.6	36.0	35.0	35.0	31.65
Mild French	9	0.0	0.0	0.0	0.0	0.00	9.4	13.0	25.0	28.9	19.08
Asian Tempest	10	0.0	16.6	10	5.0	7.90	11.1	26.6	40.0	26.8	26.13
Inchelium Red	11	32.2	33.3	33.3	45.0	35.12	67.7	46.0	75.0	70.8	65.08
Silver White	12	8.6	2.7	0.0	0.0	2.83	84.4	20.0	25.0	65.5	48.73
Early Red Italian	13	51.7	44.4	44.4	50.0	47.63	93.1	66.0	90.0	53.2	75.58
Balady (Egyptian)	5	68.8	90.5	41.7	84.0	71.25	100	95.8	53.3	90.8	84.96
Sids 40	1	60.0	68.3	34.3	79.7	60.58	85.0	93.7	75.9	92.9	86.88
Mean of locations (A)		24.14	30.51	21.87	27.87	26.10	53.14	50.11	50.12	56.11	52.37
L.S.D. at 0.05 for (A)		0.87					2.36				
(B)		0.64					2.70				
(AB)		2.09					5.40				
L.S.D. at 0.01 for (A)		1.31					3.58				
(B)		0.87					3.69				
(AB)		2.79					7.19				

Table 2. Plant height and No. of leaves/ plant of the imported and locally cultivated garlic cultivars grown at four locations under Minia and Beni Suef governorates planting conditions in winter season of 2006/2007 year.

Entry	Code No.	Plant height (cm)					No. of leaves/ plant				
		Minia Governorate		Beni Suef Governorate		Mean of entries (B)	Minia Governorate		Beni Suef Governorate		Mean of entries (B)
		Minia Univ. farm	Kaissy farm	Sids station	Yassin farm		Minia Univ. farm	Kaissy farm	Sids station	Yassin farm	
California Early	6	31.80	43.20	33.10	35.40	35.88	6.60	8.60	7.30	6.80	7.33
California Late	7	29.40	38.00	31.10	34.90	33.35	6.40	7.90	7.00	7.70	7.25
Lorz Italian	8	26.80	39.10	35.10	36.00	34.25	5.60	7.40	8.50	7.20	7.18
Mild French	9	25.80	36.80	29.50	28.90	30.25	6.00	6.90	6.50	6.00	6.35
Asian Tempest	10	15.60	28.40	21.00	26.90	22.98	5.40	6.60	7.20	7.10	6.57
Inchelium Red	11	36.20	50.80	40.60	45.60	43.30	7.60	10.20	8.50	7.80	8.53
Silver White	12	38.40	42.90	40.80	50.80	43.23	11.80	7.50	8.20	8.70	9.05
Early Red Italian	13	37.00	50.20	33.50	46.00	41.76	8.00	10.30	7.50	8.10	8.48
Balady (Egyptian)	5	56.45	65.30	55.60	65.30	60.66	9.00	9.90	7.91	10.25	9.26
Sids 40	1	56.05	67.75	58.65	64.35	61.70	10.10	10.90	9.30	10.50	10.20
Mean of location (A)		35.38	46.25	37.90	43.42	40.74	7.65	8.62	7.79	8.02	8.02
L.S.D. at 0.05 for (A)		0.92					0.51				
(B)		0.93					1.15				
(AB)		1.56					1.44				
L.S.D. at 0.01 for (A)		1.39					0.77				
(B)		1.27					1.57				
(AB)		2.07					1.91				

Table 3. Bulb characteristics of some imported and locally cultivated garlic cultivars grown under Minia governorate planting conditions in winter season of 2006/2007 year.

Entries	Average neck diameter (mm)	Average bulb diameter (cm)	Average clove number	Average bulb weight (g)	Bulb color (Visual reading)
Lorz Italian	10.2	5.8	31.0	100.1	Whitish
Early Red Italian	6.0	4.2	11.0	53.0	Whitish
California Late	10.3	5.5	35.7	73.3	Whitish
California Early	6.0	4.6	26.7	66.7	Whitish
Inchelium Red	9.2	5.0	6.00	73.3	Whitish
Mild French	No true bulbs were produced				
Silver White	No true bulbs were produced				
Asian Tempest	No true bulbs were produced				
Balady (Egyptian)	9.0	5.63	40.9	55.62	White
Sids 40	7.5	5.71	15.75	71.0	Light purple
L.S.D. at 0.05	1.34	N.S.	1.90	1.74	
0.01	1.89	N.S.	2.67	2.43	

Table (4) representing the horticultural evaluation data of the imported and locally cultivated cultivars showed that those genotypes vary much in their horticultural characteristics. "Balady" germinated faster and gave the highest germination percentage after 10 days (67.78%) and "Lorz Italian" was the slowest after this period and gave the lowest value (5.57%) but after 20 days from planting "Clone 24" showed the highest percentage (89.07%) and "California Late" gave the lowest value "14.16%). After 30 days from planting, "Early Red Italian" gave the highest germination percentage (93.30%) with insignificant difference with "Clone 24" or Balady" (92.10 and 91.67%, respectively) and "California Late" gave the lowest one "21.77%) which continued to germinate for longer than 30 days with the other germinated genotypes.

For plant height characteristic, "Clone 24" and "Clone 21" showed the tallest plants (99.700cm) and (97.867cm), respectively and plants of "Lorz Italian" were the shortest (51.933cm) with highly significant differences with the tallest plants.

Table 4. Horticultural characteristics of different imported and locally cultivated garlic cultivars and clones grown under the Minia governorate conditions in winter season of the 2007/2008 year.

Genotypes	Percentage of germination after			Plant height (cm)	No. of cloves/ bulb	Bulb Weight (g)	Fresh yield	
	10 days	20 days	30 days				Kg/plot	Ton/fed
White Brazilian	50.67	48.10	62.53	52.56	7.53	73.66	13.23	5.27
Inchelium Red	32.10	54.30	67.97	52.36	6.10	73.76	13.27	5.27
California Early	9.83	23.20	38.60	56.83	27.10	66.66	11.97	4.77
California Late	7.40	14.16	21.77	55.50	35.90	73.43	13.20	5.23
Early Red Italian	53.37	79.07	93.30	64.33	11.33	53.63	9.65	3.83
Lorz Italian	5.57	17.70	25.80	51.93	31.36	99.10	17.83	7.10
Egaseed 1	12.58	79.27	87.91	83.43	17.26	135.07	24.30	9.70
Sids 40	10.82	76.97	90.90	86.20	18.94	172.59	26.87	10.70
Clone 24	65.93	89.07	92.10	99.70	45.00	91.62	16.47	6.57
Clone 21	24.28	70.60	86.70	97.86	23.13	146.66	26.40	10.50
Balady	67.78	86.10	91.67	94.16	43.00	90.66	15.23	6.07
Mean	30.94	58.05	69.02	72.26	24.24	97.89	17.13	6.82
L.S.D. at 0.05	9.68	2.32	2.36	2.66	1.04	5.20	2.15	0.87
0.01	13.20	3.16	3.22	3.63	1.42	7.10	2.94	1.19

* All values are average of three replications.

The "Early Red Italian" was the tallest among the imported cultivars (64.333cm) and the other imported cultivars were somehow similar to each other in this characteristic (Table 4). These results indicated that some degree of selection for wide adaptability in this trait occurred in these genetic materials. These results are in harmony with those obtained by Kumar *et al.*, 1994 and Khar *et al.*, 2005.

The evaluated cultivars showed (24.244) as an average number of cloves/ bulb but the cultivars varied much in this characteristic, bulbs of some of the imported cultivars had the smallest numbers of cloves (this is a desirable characteristic), i.g., "Inchelium Red", "White Brazilian", and "Early Red Italian" (6.10, 7.53, 11.33, respectively) followed by the Egyptian cultivars "Egaseed 1" and "Sids 40" (17.267 and 18.947, respectively). On the other hand, bulbs of "Clone 24" had the highest average number of cloves (45.00) followed by "Balady" (43.00) which is well known for its big number of cloves and small clove size compared to the Chinese garlic cultivars grown in Egypt (such as "Sids 40", "Egaseed 1" and "Clone 21" as they are originally selected from the Chinese cultivars). In regards to the bulb weight, the Egyptian cultivars and clones had the higher values, "Sids 40" gave an average of (172.59 g) followed by "Clone 21" (146.66 g) and then, "Egaseed 1" (135.07 g). The lowest value of average bulb weight was given by the imported cultivar "Early Red Italian" (53.63 g) as shown in Table 1. These results confirmed those obtained by (Hussein *et al.*, 1995, Gad El-Hak and Abd El-Mageed, 2000) who found variations in bulb weight and No. of cloves/bulb within their tested garlic genotypes.

Regarding the fresh yield of bulbs, the Egyptian locally cultivated cultivars as they are adapted to the Egyptian conditions gave the highest values of fresh yield as kg/plot or ton/fed. "Sids 40" (26.47 kg/plot, 10.70 ton/fed), "Clone 21" (26.40 kg/plot, 10.50 ton/fed) and "Egaseed1" (24.30 kg/plot, 9.70 ton/fed) gave the highest values and among the imported cultivars "Lorz Italian" gave the highest values (17.83 kg/plot, 7.10 ton/fed) and "Early Red Italian" gave the lowest ones (9.65 kg/plot, 3.83 ton/fed) as shown in Table 4. The yield characteristic is affected much by the growing conditions especially day length and photoperiod time (Gad El-Hak and Abd El-Mageed, 2000, Osman and Abd El-Hameid, 1990 and Khar *et al.*, 2005).

The evaluated cultivars varied in their bulb-making behavior when the bulb and neck diameters were compared and figured out. Fig (1) showed that plants of the imported cultivars took longer time to begin bulbing and the difference between neck and bulb diameters was small at the beginning of the growing season, then it began to get bigger along with the growing season. These cultivars had thick necks when neck diameters were recorded within the growing season and were getting thinner before harvest time, "White Brazilian" and "Lorz Italian" showed the smallest values of

bulbing ratio (0.227 and 0.267, respectively). On the contrary, the cultivar "California Late" gave the highest value of bulbing ratio (0.502). The Egyptian cultivars and clones behaved different in this characteristic as these genotypes are well known for their thin necks and bigger bulbs when compared with the imported cultivars and values of the bulbing ratio of these cultivars were smaller than that of the imported cultivars (Fig 2). "Clone 24" gave the lowest value of bulbing ratio (0.167) and "Egaseed 1" gave the highest value (0.224) but still smaller than values of the imported cultivars (Fig 2). This agrees with the results obtained by (Osman and Abd El-Hameid, 1990) who claimed that garlic genotypes from different parts of the world grown in different environments vary much in their bulbing ratio.

2. Chemical composition of garlic cultivars

Data of moisture, protein, oil, ash, fiber, and nitrogen free extracts (carbohydrates) contents illustrated in Table (5) showed that there were some differences in the percentages of these chemical composition of the fresh samples from the imported and locally cultivated garlic cultivars and clones. Moisture contents were ranged between 59.13% and 71.77%. Generally, garlic has lower moisture contents when compared to other vegetables (özcan and Akgül, 1998). Our data showed that the imported garlic cultivars had higher moisture contents than the Egyptian locally cultivated cultivars and clones. The White Brazilian (an imported cultivar) showed the highest moisture content (71.77%) while the locally cultivated cultivar "Egaseed 1" showed the lowest content (59.13%) with highly significant differences between them ($P>0.01$). The other imported cultivars (Inchelium Red, California Early, California Late, Early Red Italian, and Lorz Italian) showed lower moisture contents when compared to "White Brazilian" with highly significant differences with the Egyptian genotypes and with insignificant differences when compared to each other. "Balady" which is broadly cultivated in Egypt and has a distinguished aroma showed moderate content of moisture (63.56%) when compared to all the other imported or locally cultivated cultivars, its content was higher than that of "Egaseed 1" and lower than all of the imported cultivars with highly significant differences among themIn regards to the protein content, "Balady" had the highest content of protein (10.24 %) with highly significant differences when compared to all the other imported or locally cultivated cultivars clones, and "Sids 40" had the lowest content (5.75%). The other cultivars' contents ranged between them. Values similar to our data were found in raw garlic (Hacisefroğullari *et al.*, 2005). Protein content was found to be in a considerably higher concentration than the concentration in other vegetables such as bean and pea (Cemeroğlu and Acar, 1986). As a component of protein, the intact garlic bulb contains a unique amino acid called alliin as the major

sulphur-containing amino acid, when garlic cloves are cut or crushed, alliin converts into allicin (diallyl thiosulphinate), which has the characteristic flavor of fresh garlic and is responsible for antimicrobial and anticarcinogenic properties (Velišek *et al.*, 1997). The Egyptian Balady cultivar contains high percentage of allicin in its cloves (data not shown) which makes this cultivar a good source of allicin.

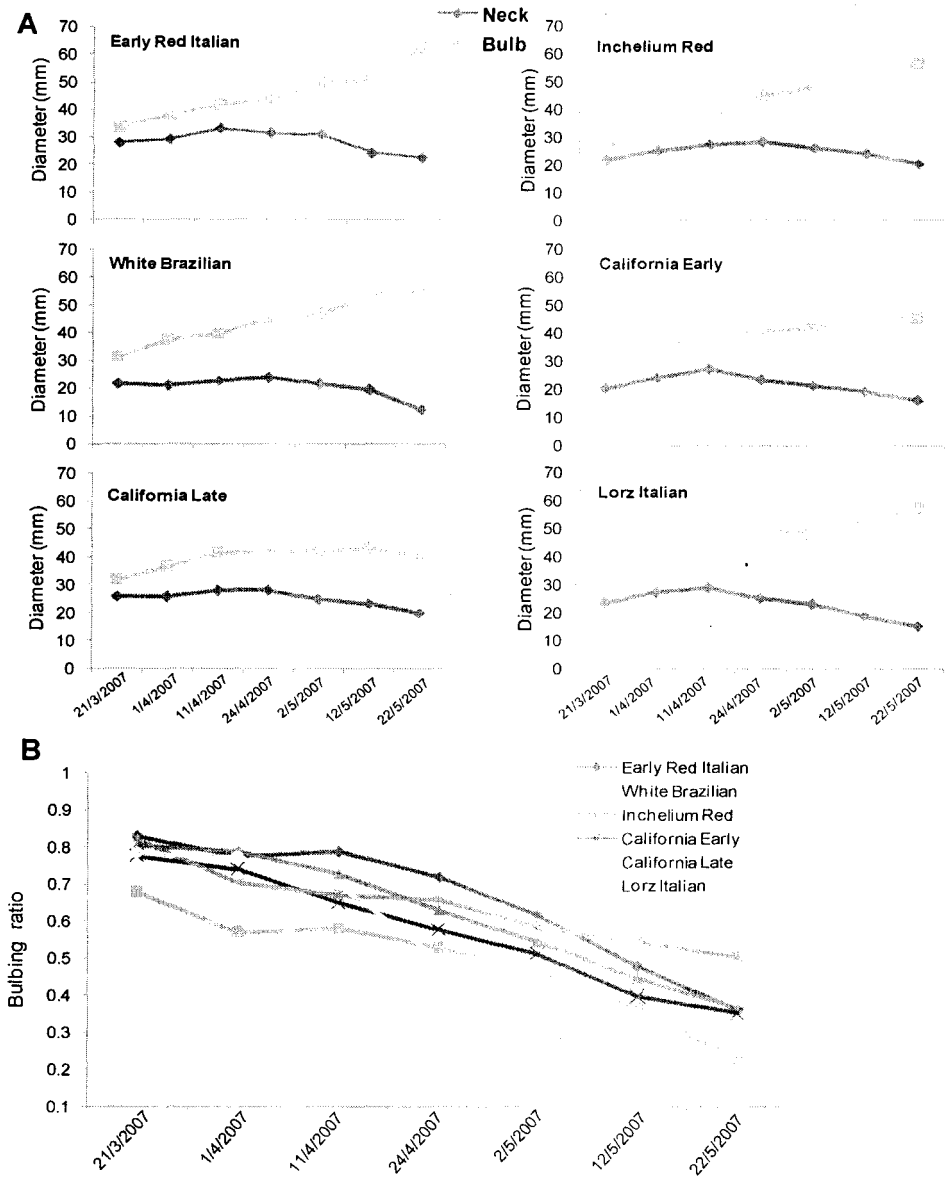

Fig 1. Neck and bulb diameter (A) and bulbing ratio (B) of the imported garlic cultivars grown under the Minia governorate conditions in winter season of 2007/2008.

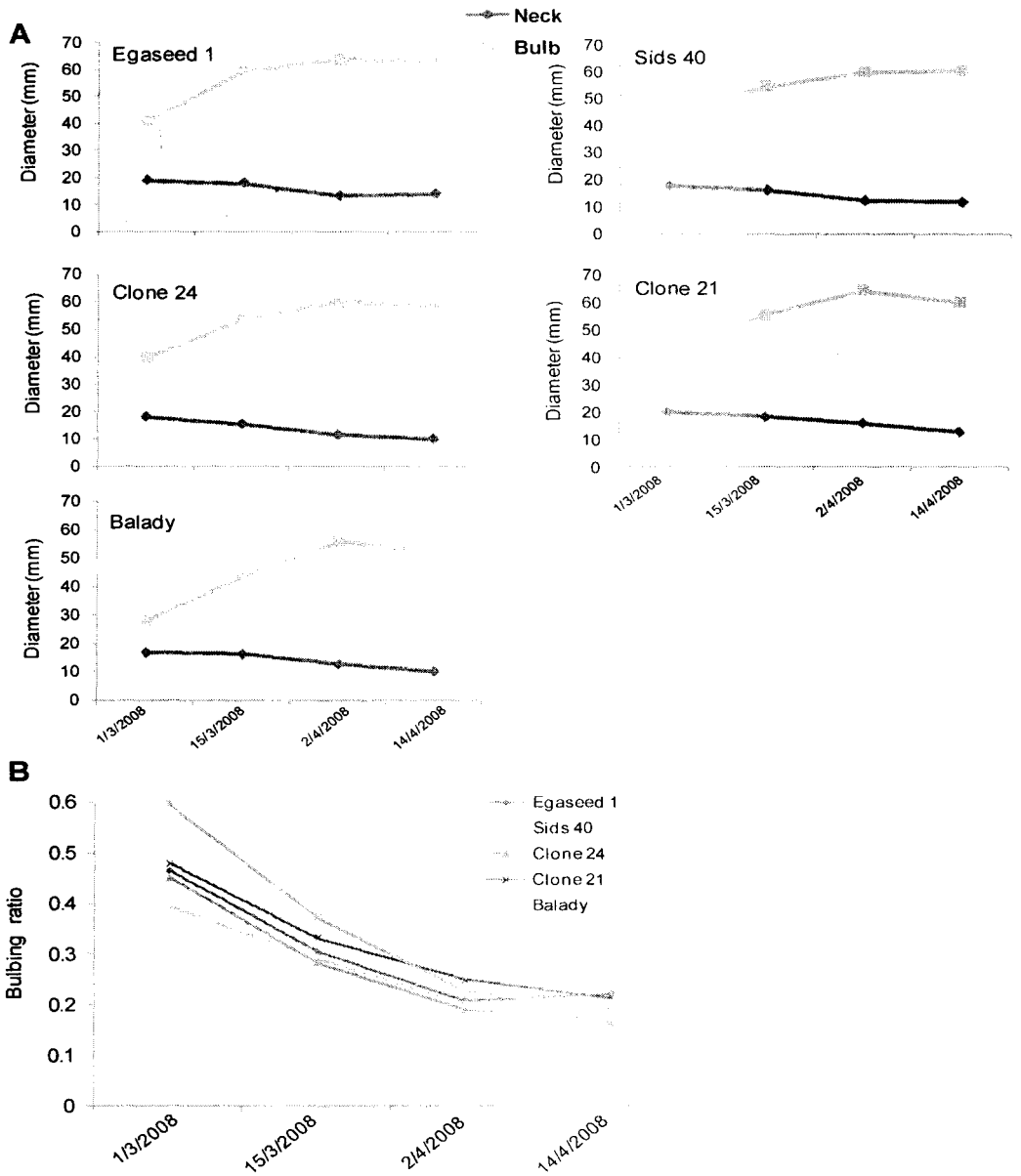

Fig 2. Neck and bulb diameter (A) and bulbing ratio (B) of the Egyptian locally cultivated garlic cultivars grown under the Minia governorate conditions in winter season of 2007/2008.

Table 5. Chemical composition of the evaluated imported and locally cultivated garlic genotypes (wet basis) grown under Minia governorate conditions in winter season of 2007/2008.

Genotypes	Moisture (%)	Crude protein % a	Crude oil %	Ash %	Carbohydrates	
					Crude fibres	Nitrogen-free extract
White Brazilian	71.77	8.99	0.723	3.233	1.073	13.423
Inchelium Red	66.50	8.11	0.837	3.000	0.983	20.467
California Early	66.43	7.39	0.840	3.733	0.860	18.980
California Late	65.23	7.97	0.973	2.333	0.970	22.173
Early Red Italian	66.76	7.41	0.510	1.433	0.907	22.733
Lorz Italian	66.50	6.74	0.840	2.210	0.967	23.840
Egaseed 1	59.13	6.39	0.900	2.600	0.915	30.113
Sids 40	60.13	5.75	0.750	1.167	0.803	29.713
Clone 24	62.13	9.75	0.763	1.200	0.970	22.630
Clone 21	60.70	7.13	0.563	1.200	0.915	28.907
Balady	63.56	10.24	0.730	1.403	0.960	22.550
Mean	64.44	7.81	0.766	2.14	0.938	23.23
L.S.D. at 0.05	1.54	0.50	0.09	0.25	0.06	0.67
0.01	2.10	0.68	0.13	0.34	0.08	0.91

* All values are average of three replications, a, N x 6.25

Crude lipid contents were ranged from 0.5% for "Early Red Italian" cultivar and 0.973% for "California Late" cultivar with highly significant differences between them (Table 5). The Egyptian cultivars and clones contained moderate and/or similar contents of crude oil when compared to the imported cultivars except "California Late" cultivar but higher than "Early Red Italian" cultivar. Our results showed an average content of crude oil (0.766%) and this value is high when compared to other published results (Haciseferogullari *et al.*, 2005), which was 0.34%. This high crude oil content in the imported and Egyptian cultivars and clones maybe due to the differences in the interaction of the genetic structure of these genotypes and the

environmental conditions. However, Egypt is well known for its suitable climate for garlic propagation along with the distinguished Egyptian horticultural practices for garlic cultivation. Garlic oil has some biological properties such as, antioxidant effects, antibacterial and antifungal activities (Bozin *et al.*, 2008).

Data in Table 5 indicated that ash values ranged from 1.167 to 3.733% and the imported cultivars gave higher values of ash than the locally cultivated clones and cultivar except for "Egaseed1" cultivar (2.600%). "California Early" cultivar gave the highest value followed by the "White Brazilian" cultivar (3.233%). The lowest value was obtained from "Sids 40" cultivar. The average obtained ash content was 2.14% and similar results were obtained in other results (Sipahtoglu and Barringer, 2003). Ash is mostly composed of salts that bind water molecules, the major minerals in garlic were established as K, P, Mg, Na, Ca, and Fe (Haciseferoğullari *et al.*, 2005).

Carbohydrates content including crude fibers and nitrogen-free extract ranged between 0.803 to 1.73% and 13.423 to 30.113%, respectively (Table 5). The "White Brazilian" imported clone gave the highest value of crude fibers compared to the local cultivated cultivar "Sids 40" with highly significant differences between them. The cultivar "Egaseed 1" gave the highest value of nitrogen-free extract content (30.113%) and the lowest value was obtained from the imported cultivar "White Brazilian". The cultivar "Sids 40" gave a value of nitrogen-free extract (29.173%) similar to "Egaseed 1" with insignificant differences between them. Hence, it can be reported that the Egyptian clones and "Balady" cultivar contained higher contents of nitrogen-free extract than the imported genotypes as they are more adapted to the Egyptian climate conditions than the imported cultivars. Our results agreed with the previously reported results by (Vanloo *et al.*, 1995) who reported that garlic contains approximately 30% oligofructo saccharides.

Contents of Nitrite NO_2^{-1} and Nitrate (NO_3^{-1})

Nitrate concentration (NO_3^{-1} mg/kg) determined in garlic extracts ranged from 25.1 to 44.6 mg/kg of fresh weight (Fig 3). The highest level (44.6 mg/ion kg) of nitrates was recorded in extracts of "California Early" and the lowest one (25.1 mg/kg) was found in "California Late". The results are in good agreement with those reported (35 mg/kg) by Van-Der-Schee, 1998). MAFF (1987) reported that nitrate concentration in vegetables vary enormously, ranging from 1 to 10000 mg/kg of fresh weight. The results are in good agreement with those reported in the applied classification of MAFF (1987) as garlic belongs to Division I, i.e. vegetables or crops containing low nitrate concentration (less than 250 mg/ion kg fwb).

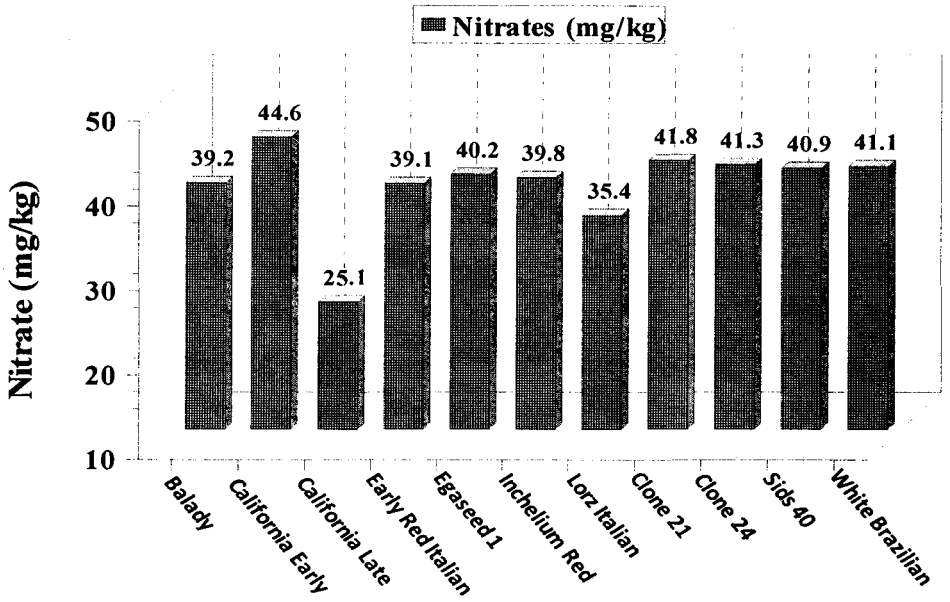

Fig 3. Nitrates (NO_3^{-1}) concentrations in garlic cultivars and clones.

Data presented in Fig (4) showed that nitrite concentrations ranged from 0.39 to 1.7 mg/kg and "Lorz Italian" cultivar contained the highest level (1.6 mg/ion kg fw). These recorded levels are within the save extent (10 mg/ion kg fw) and don't cause any toxic effects.

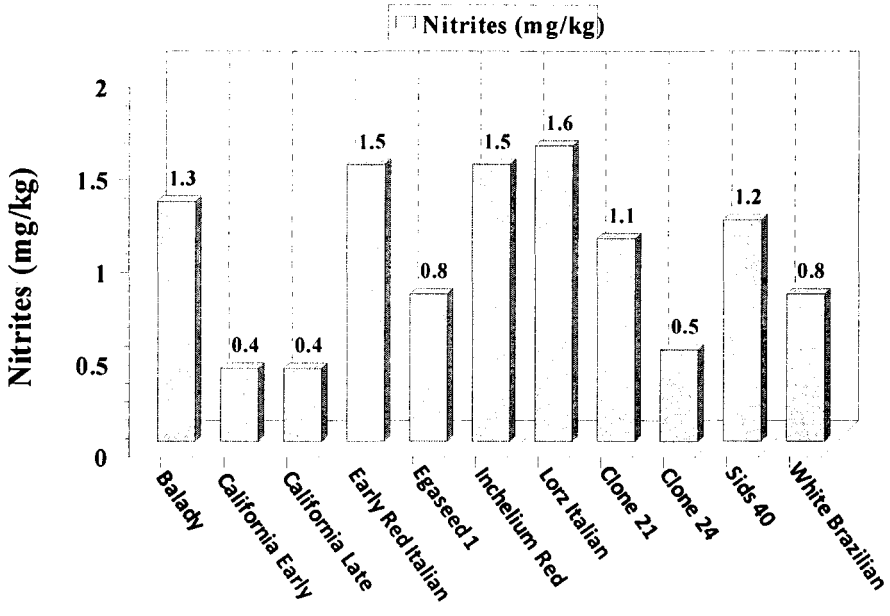

Fig 4. Nitrites (NO_2^{-1}) concentrations in garlic cultivars and clones.

The acute toxic effects of large doses of nitrite are well documented. The relatively small concentrations of nitrite to adults is judged mainly in the light of the possible role of nitrite as a precursor of the carcinogenic N-nitroso compounds. For this reason, it is important to identify those factors thought likely to increase nitrite ingestion in order to reduce the intake of this ion, since there is an evidence that high intra-gastric nitrite concentration correlates with increased risk from stomach cancer (Hartman, 1982) and the reduction of nitrate to nitrite in the gastric lumen is an important source of nitrite for formation of N-nitroso compounds.

Chung *et al.*, (2003) evaluated garlic and 14 various vegetables to nitrate contents. The average nitrite contents in various vegetables were about 0.6 mg kg^{-1}, and the values were not significantly different among most vegetables. It was observed that nitrate contents in vegetables varied depending on the type of vegetables and were similar to those in vegetables grown in other countries. It can be concluded that it is not necessary to establish limits of nitrates contents of vegetables due to the co-presence of beneficial elements such as α-tocopherol ascorbic acid which are known to inhibit the formation of nitrosamine (Hambridge, 2007). Furthermore, it has been suggested that the effects of garlic may be vascular endothelium-dependent and nitric oxide mediated. This is because its pharmacological actions appear to parallel the effects of nitric oxide. Water and alcohol extracts of garlic activate nitric oxide synthase in placenta villous tissue in a dose dependent manner. It was observed that levels of stable metabolites of nitric oxide (such as nitrate and nitrite) were significantly increased in supernatants after incubating garlic with placental villous tissue (Stevinson *et al.*, 2000). Nitrate is found naturally in foods and in high concentrations in certain vegetables. The concentrations in vegetables depend on a number of factors including season, light, temperature, method of growth, fertilizer use and storage (Dich *et al.*, 1996).

L-Ascorbic acid (L-AA) content in garlic samples

L-AA concentrations ranged from 3.63 (White Brazilian) to 7.55 mg/100g (Clone 24). The levels of L-AA in "Balady" cultivar, "California Early" and "California Late" are close to 6 mg/100g, these values are lower than those determined in tomatoes (12 mg/100g) and much lower than sweet potato values (14 mg/100g).

Most staples and vegetables, including garlic contain vitamin C in both the reduced (L-ascorbic acid) and oxidized (dehydroascorbic acid) forms. Vitamin C is a powerful reducing agent found in millimolar concentrations in plants, and is thought to play an important role in scavenging free radicals (a natural antioxidant) in plants and animals (Conklin *et al.*, 1996 and Abd El-Naem, 2004). Fortunately, it is an important

nutritive compound in garlic cloves. Moreover, the role of L-ascorbic acid in prevention of curvy and many disease infections has been known for a long time (Secretin, 1974).

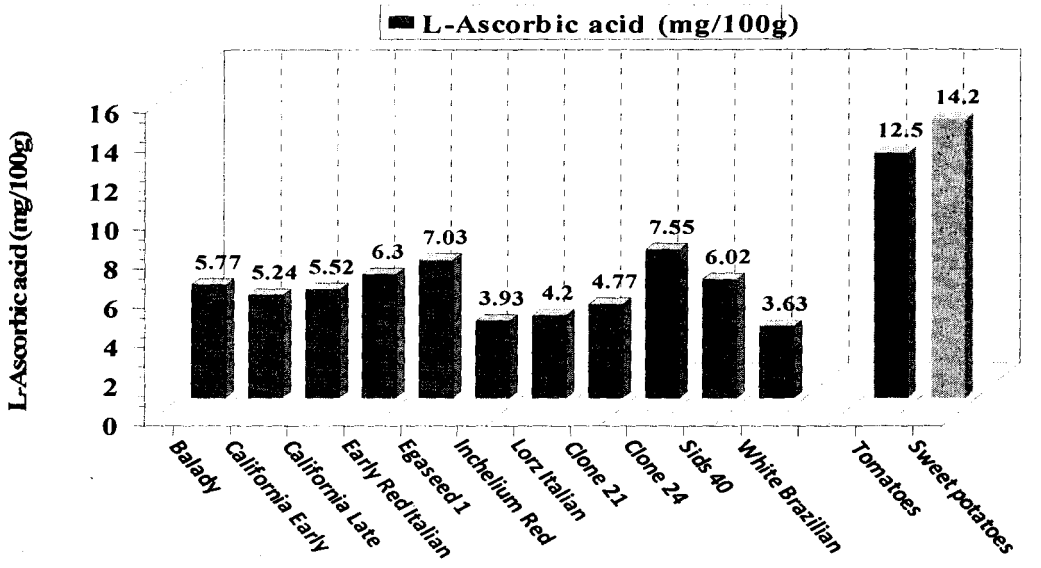

Fig 5. L-Ascorbic acid levels in garlic cultivars and clones.

Total phenolic compounds in garlic samples

Concentrations of TPCs are given in Fig (6). The highest levels of TPCs were recorded in the HCl-methanolic extracts to be 18.6 and 18 mg/100g of "California Early" and "California Late", respectively, but the lowest one was found in extract of "Egaseed1" (8.6 mg/100g fresh weight). Our results indicated that the TPCs concentration in extracts of both "Balady" and "Sids 40" cultivars are equal (15.8 mg/100g fresh weight). The functions of TPCs are extensively discussed by many investigators from two different points of view. First of them, it consider TPCs are defensive compounds which naturally synthesize and play important roles against insects and pathogens attacks (positive effects), but the second is based from the nutritionists who classified TPCs as antinutritional factors (ANFs) (negative effects) and proposed various processing treatments to eliminate them from crop tissues. There is increasing evidence that consumption of a variety of phenolic compounds present in natural foods (fresh vegetables) may lower the risk of serious health disorders because of the antioxidants activity of these compounds (Keli *et al*/ 1996).

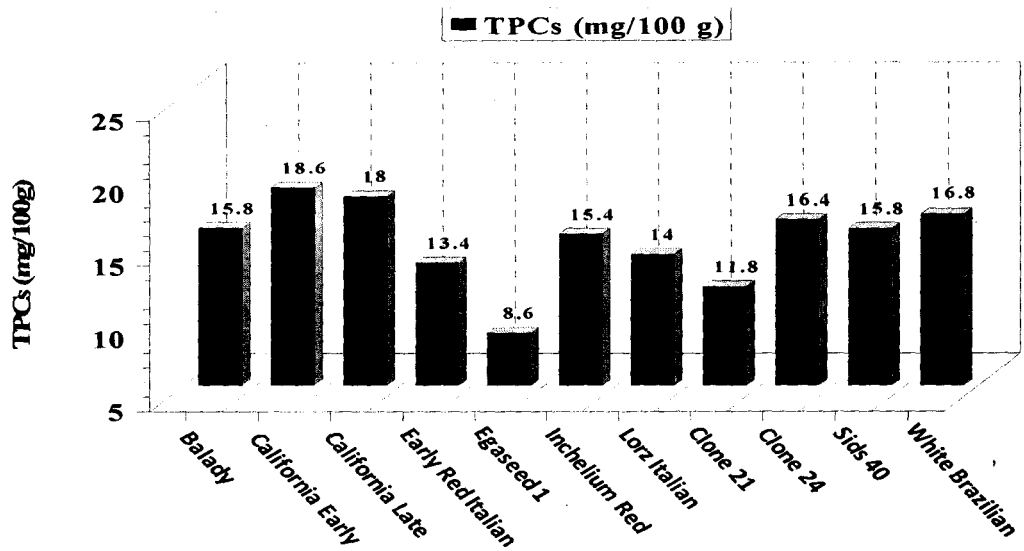

Fig 6. TPCs levels in garlic cultivars and clones.

Polyphenols are reducing agents, and together with other dietary reducing agents, such as vitamin C, vitamin E and carotenoids, protect the body tissues against oxidative stress. Commonly referred to antioxidants, which may prevent various diseases associated with oxidative stress, such as cancers, cardiovascular diseases, and inflammation.

Total flavonoids (TFs) content

Total flavonoids content was assayed and the results showed that "Clone 24" had the highest level (10.9 µg/g) of flavonoids followed by "California Early" (8.91 µg/g) (Fig 7). On the other hand, the lowest levels (2.17 and 2.51 µg/g) were recorded in tissues of "Clone 21" and "Early Red Italian", respectively. Many investigators concluded that pharmacological effects of flavonoids are correlated with their antioxidant activities. Moreover, it is suggested that the overall antioxidant effect of flavonoids on lipid peroxidation may be related to their $^{\cdot}OH$ and $^{\cdot}O_2$ scavenging properties and their reaction with peroxy radicals (Zhishen *et al.,* 1999 and Luthria, and Corrales, 2006).

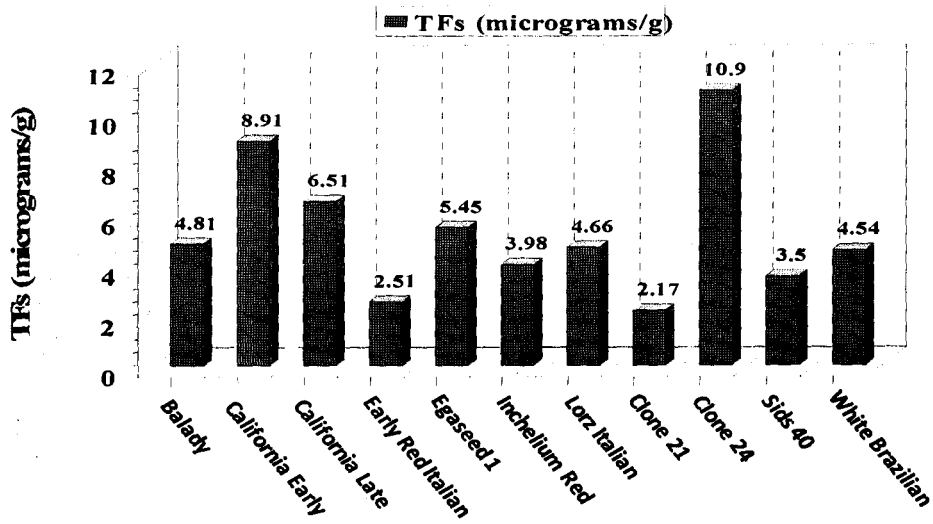

Fig 7. TFs concentrations in garlic cultivars and clones.

Flavonoids are different from other phenolic substances in the degree of oxidation of their central pyran ring and biological properties. While some classes (such as flavonones, for example) are colorless, the members of other classes (such as anthocyanes, for example) are always colored and known as pigments of flowers or other plant parts. Anthocyanes are normally red or yellow, their color is pH-dependent. Blue pigments are achieved by chelate formation with certain metal ions (Fe^{III} or Al^{III}, for example) as reported by Keli *et al.*, 1996. Identification of the genes controlling flavonoid and tannin formation, along with knowledge of the antioxidant activity of these compounds, may enable plant breeders to select garlic varieties that have a range of antioxidant activities and also, perhaps, balance the positive effects of antioxidant activity in diets with phenolic effects.

Some of the imported could be grown under the Egyptian growing conditions. Their content of protein, ascorbic acid, total phenolic compounds, total flavonoids along with their accepted fresh yield, lower number of cloves/bulb and bulb white color make them promising new cultivars for garlic cultivation in the Middle Egypt in the coming years. The best among was the White Brazilian clone which maybe the most promising one with its desirable obtained characteristics. These imported genotypes will be grown in our farm in the coming seasons to concentrate their promising adaptability behavior to the Middle Egypt conditions and to become stable, we will practice clonal selection method as a breeding program among those genotypes in the coming years to release good clones in Egypt.

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سلوك بعض أصناف الثوم المستوردة حديثاً والمنزرعة تحت ظروف الزراعات المصرية

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تم استيراد تسعة أصناف من الثوم الأجنبي وهى (White Brazilian, Inchelium Red, California Early, California Late, Early Red Italian, Lorz Italian, Mild French, Asian Tempest, Silver White) إلي مصر لأول مرة وتم تقييمها مع ثلاثة أصناف مصرية وسلالتين (البلدى ، سدس ٤٠ ، إيجاسيد ١، السلالة ٢٤ والسلالة ٢١) تحت الظروف المصرية وتم زراعتها وتقييمها فى أربعة مواقع بمصر الوسطى (إثنين بمحافظة المنيا بمزرعة كلية الزراعة بجامعة المنيا ومزرعة القيسى) وإثنين في محافظة بنى سويف (بمزرعة محطة بحوث سدس ومزرعة العقيد ياسين) وذلك فى شتاء ٢٠٠٦/٢٠٠٧ وتم تقييم نمو هذه الأصناف فى المواقع الأربعة. ثم زرعت الأبصال الحقيقية التى أنتجت من هذه الأصناف (ما عدا الأصناف Mild French, Asian Tempest, Silver White التى لم تعطى أبصال حقيقية) بمزرعة كلية الزراعة بجامعة المنيا فى شتاء ٢٠٠٧/٢٠٠٨، وفى هذا الموسم الثانى الذى رُكزت الدراسة عليه أظهرت الأصناف عامة نتائج جيدة وأظهرت الأصناف والسلالات المصرية معظم الصفات البستانية والكيميائية المرغوبة بسبب تأقلمها مع الظروف المصرية، فقد أظهرت السلالة ٢٤ أعلى نسبة إنبات للفصوص بعد ١٠، ٢٠، و٣٠ يوم من الزراعة (٦٥,٩٣، ٨٩,٠٧، و ٩٢,١٠ % على الترتيب) وكان مثيلها الصنف Early Red Italian (٩٣,٣%) بعد ثلاثين يوم فقط من الزراعة وكذلك كانت نباتاته أطول النباتات (٩٩,٧ سم) وصنف سدس ٤٠ أعطى أعلي قيم لأوزان الأبصال ١٧٢,٥٦ والمحصول الطازج (26.87 كجم/ قطعة تجريبية و١٠,٧٠ طن/فدان) وأظهر الصنف البلدي أعلي قيمة من محتوى البروتين (١٠,٢٤%) وصنف ايجاسيد ١ لأعلي قيم للكربوهيدرات (٣٠,١١%) مع عدم وجود معنوية بينهما. ومن ناحية أخري أظهرت الأصناف المستوردة أقل قيمة لعدد الفصوص في البصلة (٦,١) للصنف Inchelium Red وهذه صفة مرغوبة وأعلي نسبة رطوبة (٧١,٧٧%) للصنف White Brazilian. وسُجلت أعلي نسبة للبيبدات الكلية (٠,٩٧%) في الصنف California Late وأعلي نسبة للرماد (٣,٧٣%) والصنف California Early وأعلي نسبة للألياف (١,٠٤٧%) في الصنف White Brazilian.

كما تم دراسة تركيز النترات فى الأصناف المنزرعة وكانت النسبة تتراوح بين ٢٥,١ و ٤٤,٦ ملليجرام/كجم وكان أعلي مستوي للنترات (٤٤,٦) فى مستخلصات الصنف California Early وتراوح تركيز نسبة النيتريت من ٠,٣٩ الي ١,٧٠ ملليجرام/كجم وأعلي تركيز سجل في الصنف Lorz Italian كما تتراوح نسبة تركيز حمض الأسكوربيك من ٣,٦٣ الي ٧,٥٠ ملليجرام/١٠٠ جم وسُجل أعلي تركيز منه في مستخلصات السلالة ٢٤ وسُجل أعلي مستوي من تركيز المركبات الفينولية الكلية TPCs (١٨,٦ ملليجرام/ ١٠٠ جم) للصنف California Early و ١٨,٠ ملليجرام/١٠٠ جم للصنف California Late وتم تقدير المحتوي من الفلافونيدات الكلية TFs وكان أعلي تركيز منها (١٠,٩ ميكروجرام/جم) للسلالة ٢٤.

ونستنتج من هذه الدراسة أن هذه الأصناف المستوردة أظهرت قابلية جيدة للتأقلم مع الظروف المصرية خاصةً فى مصر الوسطى المناسبة جداً لزراعة الثوم خصوصاً أن هذه الأصناف تميزت بمحتوى عالى من البروتين وحامض الأسكوربك والمركبات الفينولية الكلية TPCs والمحتوي من الفلافونيدات الكلية TFs والتى تدخل فى إنتاج المركبات الطبية الصيدلية، وأبصالها ذات لون أبيض وذات عدد قليل من الفصوص فهى ستواكب ذوق المستهلك المصرى ومن ثم ينصح بزراعة هذه الأصناف لعدة مواسم حتى تتأقلم مع الظروف المصرية تماماً ويتم الإنتخاب خلالها ويتم الحصول على سلالات جديدة ذات إنتاج عالى وصفات بستانية جيدة ومن ثم يتم توزيعها على مزارعى الثوم بمصر الوسطى فقد تحذو حذو الأصناف الصينية المنتشر زراعتها فى مصر منذ سنوات.