EFFECT OF FRUIT HARVEST TIME AND USED PART OF SEVERAL GENOTYPES OF BITTER GOURD (*MOMORDICA CHARANTIA* L.) ON THEIR CHEMICAL PROPERTIES AND CONTENT OF MEDICINALLY ACTIVE COMPOUNDS

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ABSTRACT

The experiment was conducted at a greenhouse in the College of Agricultural Engineering Sciences - University of Baghdad during 2019-2020 season , relying on the randomized complete block design (RCBD) in a split-split plot order, with three replications. The experiment included three factors. The first factor was four bitter gourd genotypes, symbolized by C, B, G, and H; the second factor was reaping the fruit at the age of 10, 20, and 30 days; and the third factor was using the fruit as a whole or without seeds (E and F); thus, the experiment included 72 experimental units. The results showed that the triple interaction treatment GE20 recorded the highest concentration of momaodin, reaching 13.53 mg.g-1, and the BE10 treatment recorded the highest concentration of total phenols, reaching 02.39 mg.g-1. The binary interaction treatments CF20 and C20 recorded the highest charanitinconcentration in the fruits, reaching 1.180 mg.g-1 and 0.877 mg.g-1.The treatments HF, G20, and E20 produced the highest concentration of momordin, amounting to 273, 7.908, and 5.097 mg.g-1, respectively. The binary interaction treatments BE and B10 were superior, recording the highest concentration of total phenols, reaching 2.178 and 2.091 mg.g-1, respectively. Concerning the individual factors, genotype C was superior in charanitin concentration, producing 0.451 mg.g-1; in contrast, the G genotype recorded the highest concentration of momordin, amounting to 4.199 mg.g-1, which did not differ significantly from genotype H, which recorded 3.454 mg.g-1. Genotype B gave the highest concentration of total phenols, reaching 1.855 mg.g-1. Concerning the individual factors, genotype C was superior in charanitin concentration, producing 0.451 mg.g-1; in contrast, the G genotype recorded the highest concentration of momordin, amounting to 4.199 mg.g-1, which did not differ significantly from genotype H, which recorded 3.454 mg.g-1. Genotype B gave the highest concentration of total phenols, reaching 1.855 mg.g-1.

Key world: fruits age ,Charantin, Momordin, and total phenols.

INTRODUCTION

Medicinal plants are the basis of primary health care for the majority of the world's population and an essential source of income in many countries, especially many residents of developing countries depend on alternative medicine systems to treat many diseases, as well as being a primary source of raw materials for the medicine manufacture. In recent years, the use of herbal medicines has become more prevalent due to their lack of side effects when used in a scientific and thoughtful manner as compared to the harmful side effects of many chemical medicines. Additionally, the growing demand for herbal medicines has led to the commercial cultivation and production of medicinal plants (3; 45; 14). One of the essential

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medicinal plants is bitter gourd, Momordica charantia, which belongs to the Cucurbitaceae family and is used to treat various diseases (38; 29). According to studies conducted by (45), and (10) , bitter gourd is a great natural remedy for diabetes. It contains charantine , which helps to increase insulin secretion in the pancreas and reduce the absorption of glucose in the intestines. Other studies conducted by (16), (49), (26), and (22) have also shown similar results. Furthermore, it has been found to delay complications that may arise in diabetic individuals (46, 25). The raw extract of bitter gourd, containing Momordin, is used as an anti-cancer, especially lymphocytic leukemia, lymphoma, skin cancer, breast cancer, and prostate and bladder cancer (34, 12). It was found that the aqueous extract of bitter gourd peels prevents the growth of tumors in the breasts and prostate of mice (19, 36,18, 39). It can also improve the function of immune cells in people with cancer (19, 13), and phenolic compounds are of great importance as antioxidants (2). Determining the fruit reap age or the plant part, whether it is the fruit or other parts of medicinal plants, is a crucial process from a nutritional, health, and economic standpoint, as it affects the plant content of the nutrients and medicinally active compounds. (48) found that the concentration of volatile oil and its basic components varied based on the time of guava leaf collection. In a study conducted by researcher (17) on the effect of planting and harvesting dates on Talinum triangulare plant, they concluded that there is a significant effect on the concentration of phenolic compounds and antioxidants with different harvesting dates. (54) reported that cutting the leaves of Horseradish plant Armoracia rusticana L. at different dates clearly affected the concentration of phenolic compounds and antioxidants. (52) found that reaping five genotypes of strawberries at different dates clearly affected the concentration of anthocyanin and phenolic compounds in the fruits. (30) found, in an experiments on licorice plants, that harvesting the roots at two different dates significantly affected the concentration of protein, sugars, and antioxidants.(20) also found that harvesting the rosemary plant at various dates had a significant effect on the volatile oil concentration of the as well as the active components involved in the composition of the oil. (44) also reported that harvest dates and the use of mycorrhizae on the aromatic plant significantly affected the concentration of the volatile oil and its components. In a study on sugar beet plants, (50) found significant differences in the concentration of sugars depending on harvest dates. (5) referred that deriving genotypes by hybridization led to dramatic differences in the concentration of charanitin and momordin depending on the parents' genotypes.(9) also found differences in the distribution of phenolic compounds in the taxonomic ranks of the genus Clinopodium. A study on L. Pelargonium graveolens revealed significant differences in the concentration of the active components for different plant parts (37). In a study, conducted on various plant parts of the Cruciferous family, (24) confirmed high differences in the concentration of the active substances, and differences in their effect on cancer cells. (7), in a study on Leucaena leucocephala L., when taking different parts of the plant, found significant differences in the concentration of active substances according to the plant part. (1), studying several genotypes of corn, found significant differences in the vegetative and chemical characteristics of the studied plants. (28), while studying Astragalus bruguieri, found significant differences in the concentration of medicinal compounds differed with different investigated plant parts.This research aims to determine the best reaping time, the using fruit part, and the genotypes of bitter gourd relying on the concentration of the medically active substances and nutritional elements in the fruit.

MATERIALS AND METHODS

The experiment was implemented in a greenhouse affiliated with the College of Agriculture - University of Baghdad - Al-Jadriya, involving planting four genotypes of bitter gourd (Table 1) on terraces with a 50 cm distance between plants, based on the split plots arrangement of two factors. The treatments were replicated three times within the randomized complete block design (RCBD). The first factor was the bitter gourd genotypes; the second factor was reaping the fruit at three ages (10, 20, and 30 days); and the third factor was the fruit (whole fruit, symbolized by E, and the seedless fruit, symbolized by F) thus, the experiment comprised 72 experimental units.

Table 1. Genotypes included in the study, their symbols, conditions, and morphological characteristics

Experimental code	**Bank code**	**Genotype state**	**Genotype characteristics**
H	365	Hybrid	characterized by its strong growth, with large fruits that contain many grooves
G	225	Hybrid	characterized by its small, green fruits that contain many bumps
B	168	Line	a strong-growing line with large, elongated fruits with dark green color, containing many bumps
C	155	Line	characterized by elongated, light green fruits with numerous grooves on the surface

Samples were taken from the fruits of the experimental units (the whole fruit as well as the fruits from which the seeds were removed); next, they were cut into small slices to facilitate their drying; then, they were dried in an electric oven at a temperature of 40°C until the weight was stable and stored until they were used to estimate the nutritional elements and the concentration of some active compounds in fruits.

- Concentration of Charantin and Momordin (mg.100g-1) according to (53).
- Concentration of total phenols
  Total phenols in the fruits were estimated according to the Folin-Ciocalteau procedure (51).
- Nitrogen percentage (N%), estimated according to (30).
- Phosphorus percentage (P%), estimated according to (39).
- Potassium percentage (K%), according to (40).
- Protein percentage, estimated in fruit based on the dry weight according to the following equation

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- Protein percentage based on the dry weight = nitrogen percentage x 6.25

RESULTS AND DISCUSSION

1- Effect of the reaping age of the fruits and the using fruit part of several bitter gourd genotypes on the concentration of Charantin, Momordin, and total phenols in the fruits.

Results in Table 2a demonstrate significant differences between the reaping fruit age, fruit part used, and the genotypes in the concentration of Charantin, Momordin, and total phenols of bitter gourd. The interaction treatments, CF20 and GE20, produced the highest concentration of Charanitin (1.180mg.g-1) and Momordin (13.53 mg.g-1), outperforming all triple intersection treatments. The two treatments, BE10 and CE10, were superior in the concentration of total phenols, giving the highest values of 02.39 mg.g-1 and 2.323 mg.g-1, respectively, compared to treatment GF30, which gave the lowest concentration of 1.046 mg.g-1.

Results in Table 2b refer to significant differences in the binary interactions between the using fruit parts and the bitter gourd genotypes in the concentration of Charantin, Momordin, and total phenols in the fruits. The seedless fruit of the line C (CF) gave the highest Charanitin concentration in the fruits, reaching 0.692 mg.g-1., compared to the treatment HF, which gave the lowest charanitin concentration of 0.060 mg.g-1. As for the interaction between the genetic structure and the fruit age, the treatment C20 was superior, giving the highest Charanitin concentration, amounting to 0.877 mg.g-1, compared to the H20 treatment, which gave the lowest Charanitin concentration of 0.021 mg.g-1. In contrast, results in Table 2c showed that the effect of the interaction between the fruit part used and the fruit age on the Charanitin concentration was insignificant. The binary interaction treatment between the genotypes and the fruit part used (GE) also recorded the highest concentration of Momordin, reaching 7.327 mg.g-1 compared to the lowest value given by the treatment BF, which produced 0.147 mg.g-1 of Momordin. The interaction between the genotypes and the fruit age G20 gave the highest concentration of Momordin, reaching 7.908 mg.g-1 compared to treatment B10, which gave the lowest value of 0.075 mg.g-1. The interaction treatment between the fruit age and the fruit part used E20 gave the highest Momordin concentration, reaching 5.097 mg.gm-1, compared to treatment E30, which gave the lowest value of momordin concentration, 0.844 mg.gm-1.

Table 2a. Effect of the triple interaction between the reaping fruit age, fruit part used, and genotypes on the concentration of carnitine, momordin, and total phenols in the bitter gourd fruits (mg.g-1).

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Treatments	Charantin	momordin	phenols
HF10	0.027	10.85	1.610
HE10	0.196	0.049	2.296
GF10	0.947	0.558	1.570
GE10	0.028	8.199	2.233
BF10	0.252	0.081	1.793
BE10	0.348	0.070	2.390
CF10	0.048	0.295	1.706
CE10	0.035	0.424	2.323
HF20	0.016	2.187	1.420
HE20	0.026	2.354	2.073
GF20	0.486	2.280	1.386
GE20	0.016	13.53	2.013
BF20	0.183	0.073	1.520
BE20	0.046	4.488	2.166
CF20	1.180	0.216	1.486
CE20	0.573	0.010	2.113
HF30	0.136	2.774	1.166
HE30	0.469	2.501	1.820
GF30	0.139	0.379	1.046
GE30	0.025	0.243	1.830
BF30	0.215	0.287	1.280
BE30	0.270	0.478	1.980
CF30	0.847	0.105	1.296
CE30	0.020	0.154	1.913
L.S.D (0.05)	0.206	1.182	0.067

Knowing that H, G, B, and C = genotypes, F = the fruit without seeds, E = the whole fruit, 10 = the fruit is ten days old, 20 = the fruit is 20 days old, and 30 = the fruit is thirty days old.

The results of Table 2b refer to the superiority of the treatment BE, which gave the highest concentration of total phenols, amounting to 2.178 mg.g-1, compared to the GF treatment, which gave the lowest value of the trait, reaching 1.334 mg.g-1. The treatment of the interaction between genotypes and the fruit age, B10, recorded the highest concentration of phenols, reaching 2.091 mg.g-1, compared to treatment G30, which gave the lowest phenol concentration of 1.438 mg.g-1. The interaction treatment between the fruit age and the fruit part used, E10, also produced the highest phenol concentration of 2.310 mg.g-1, compared to treatment F30, producing the lowest phenol concentration of 1.197 mg.g-1.

It is noticed from the results in Table 2c that genotype C was superior to the rest of the genotypes in Charanitin concentration, giving the highest value, reaching 0.451 mg.g-1. Genotype, G gave the highest Momordin concentration, amounting to 4.199 mg.g-1, compared to the lowest value given by genotype C, 0.201 mg.g-1. Genotype B produced the highest concentration of total phenols, amounting to 1.855 mg.g-1, compared to the lowest value of total phenols concentration shown by genotype G. Table 2c shows that for the fruit part used, treatment F was superior in The Charanitin concentration, recording 0.373 mg.g-1, and treatment E was superior in giving the highest concentration Momordin and phenols, amounting to 2.709 mg.g-1 and 2.09 mg.g-1, respectively. Regarding the fruit age, Table 6 shows that reaping the fruit at the age of 20 days gave the highest concentration of Charanitin and Momordin, reaching 0.316 and 3.14 mg.g-1, respectively. In contrast, reaping fruits at the age of 10 days, recorded the highest concentration of total phenols, reaching 1.99 mg.g-1

Table 2b. Effect of the binary interaction between the reaping fruit age, fruit part used, and genotypes on the concentration of charanitin, momordin, and total phenols in the bitter gourd fruits (mg.g-1).

genotype and fruit part	Charantin	Momordin	Phenols
HF	0.060	5.273	1.398
HE	0.230	1.635	2.063
GF	0.524	1.072	1.334
GE	0.023	7.327	2.025
BF	0.217	0.147	1.531
BE	0.221	1.679	2.178
CF	0.692	0.205	1.496
CE	0.209	0.196	2.116
L.S.D (0.05)	0.128	0.777	0.047
Interaction between genotype and Fruit age			
H10	0.112	5.453	1.953
G10	0.487	4.378	1.901
B10	0.300	0.075	2.091
C10	00.42	0.360	2.015
H20	0.021	2.271	1.746
G20	0.251	7.908	1.700
B20	0.114	2.280	1.843
C20	0.877	0.113	1.800
H30	0.302	2.638	1.493
G30	0.082	0.311	1.438
B30	0.242	0.383	1.630
C30	0.433	0.129	1.605
L.S.D (0.05)	0.1520	0.829	0.067
Interaction between fruit part and fruit age			
F10	0.319	2.948	1.670
E10	0.466	2.186	2.310
F20	0.334	1.189	1.453
E20	0.152	5.097	2.091
F30	0.165	0.886	1.197
E30	0.196	0.844	1.885
L.S.D (0.05)	N.S	0.6229	0.033

Knowing that H, G, B, and C = genotypes, F = the fruit without seeds, E = the whole fruit, 10 = the fruit is ten days old, 20 = the fruit is 20 days old, and 30 = the fruit is thirty days old.

Table 2c. Effect of the genotypes, fruit part used, and fruit age on the carnitine, momordin, and total phenols (mg.g-1) of the bitter gourd

Geno type	Charantin	Momordein	phenols
H	0.145	3.454	1.731
G	0.273	4.199	1.680
B	0.219	0.913	1.855
C	0.451	0.201	1.806
L.S.D (0.05)	0.110	0.573	0.032
Fruit part			
F	0.373	1.674	1.44
E	0.171	2.709	2.09
L.S.D (0.05)	0.0645	0.4503	0.019
fruit age			
10	0.235	2.567	1.99
20	0.316	3.14	1.77
30	0.265	0.865	1.54
L.S.D (0.05)	0.073	0.414	0.024

Knowing that H, G, B, and C = genotypes, F = the fruit without seeds, E = the whole fruit, 10 = the fruit is ten days old, 20 = the fruit is 20 days old, and 30 = the fruit is thirty days old.

1- Effect of reaping fruit age, fruit part used, and genotypes on the percentage of nitrogen, phosphorus, potassium, and proteins of bitter gourd fruits

Results in Table 3a show significant differences in the interaction between the reaping fruit age, fruit part used, and several genotypes of bitter gourd in the percentage of nitrogen, phosphorus, potassium, and protein in the fruits. It is noticed that treatment GF30 gave the highest values for the percentage of nitrogen, protein, and phosphorus (1.60%, 10.06%, and 0.710%, respectively), and treatment CF30 gave the highest potassium percentage, amounting to 2.696%, compared to the lowest percentage of nitrogen and protein given by treatment BE10 (1.313% and 8.206%, respectively). Treatment BE20 gave the lowest phosphorus percentage, reaching 0.423%. The GE10 treatment recorded the lowest potassium percentage, reaching 1.486%.

Results in Table 3d refer to the superiority of the binary interaction treatment GF in the percentage of nitrogen, protein, and phosphorus, recording 1.522%, 9.512%, and 0.680%, respectively. Treatment CF showed the highest percentage of potassium (2.392%) compared to the interaction treatment BE, which gave the lowest percentage of nitrogen, protein, and phosphorus, amounting to 1.386%, 8.662%, and 0.50%, respectively; in contrast, GE exhibited the lowest potassium percentage (1.582%).

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Table 3a. Effect of the triple interaction between the reaping fruit age, fruit part used, and several genotypes on the percentage of nitrogen, phosphorus, potassium, and proteins in the bitter gourd fruits

Treatments	N%	P%	K%	protein
HF10	1.286	0.623	1.616	8.037
HE10	1.380	0.643	1.616	8.625
GF10	1.473	0.647	1.610	9.206
GE10	1.406	0.634	1.486	8.787
BF10	1.383	0.593	1.873	8.643
BE10	1.313	0.490	1.550	8.206
CF10	1.400	0.643	2.143	8.750
CE10	1.330	0.423	1.773	8.312
HF20	1.463	0.666	1.683	9.143
HE20	1.426	0.649	1.613	8.912
GF20	1.483	0.683	1.71	9.268
GE20	1.493	0.672	1.62	9.331
BF20	1.456	0.650	1.933	9.100
BE20	1.390	0.440	1.643	8.687
CF20	1.483	0.660	2.336	9.268
CE20	1.413	0.582	1.823	8.831
HF30	1.550	0.700	1.706	9.687
HE30	1.506	0.676	1.746	9.412
GF30	1.610	0.710	1.806	10.06
GE30	1.453	0.670	1.640	9.081
BF30	1.500	0.683	1.846	9.375
BE30	1.456	0.570	1.650	9.100
CF30	1.586	0.690	2.696	9.912
CE30	1.496	0.640	1.926	9.350
L.S.D (0.05)	0.094	0.029	0.088	**0.589**

Knowing that H, G, B, and C = genotypes, F = the fruit without seeds, E = the whole fruit, 10 = the fruit is ten days old, 20 = the fruit is 20 days old, and 30 = the fruit is thirty days old.

Table 3b. Effect of the binary interaction between the reaping fruit age, fruit part used, and several genotypes on the percentage of nitrogen, phosphorus, potassium, and proteins in the bitter gourd fruits

Interaction between **genotype and fruit part**	**%N**	**P%**	**K%**	**Protein%**

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HF	1.433	0.663	1.668	8.956
HE	1.437	0.656	1.658	8.981
GF	1.522	0.680	1.708	9.512
GE	1.451	0.659	1.582	9.068
BF	1.446	0.642	1.884	9.037
BE	1.386	0.500	1.614	8.662
CF	1.490	0.6644	2.392	9.312
CE	1.413	0.5487	1.841	8.831
L.S.D (0.05)	0.094	0.017	0.058	0.589
Interaction between genotype and fruit age				
H10	1.333	0.633	1.616	8.331
G10	1.440	0.641	1.548	9.000
B10	1.348	0.541	1.711	8.425
C10	1.365	0.533	1.958	8.531
H20	1.445	0.657	1.648	9.031
G20	1.488	0.678	1.665	9.300
B20	1.423	0.545	1.788	8.893
C20	1.448	0.621	2.080	9.050
H30	1.528	0.688	1.726	9.550
G30	1.531	0.690	1.723	9.568
B30	1.478	0.626	1.748	9.237
C30	1.541	0.665	2.311	9.631
L.S.D (0.05)	0.066	0.022	0.066	0.412
Interaction between **fruit part** and fruit age				
F10	1.385	0.6269	1.810	8.656
E10	1.357	0.5477	1.606	8.481
F20	1.471	0.665	1.915	9.193
E20	1.430	0.5861	1.675	8.937
F30	1.561	0.6958	2.014	9.756
E30	1.478	0.6392	1.740	9.237
L.S.D (0.05)	0.048	**N.S**	**N.S**	0.300

Knowing that H, G, B, and C = genotypes, F = the fruit without seeds, E = the whole fruit, 10 = the fruit is ten days old, 20 = the fruit is 20 days old, and 30 = the fruit is thirty days old.

Concerning the binary interaction, the interaction treatment C30 between the genotypes and reaping fruit time was superior in the percentage of nitrogen, proteins, and potassium, achieving 1.541%, 9.631, and 2.311%, respectively, compared to the lowest percentage given by treatment H10, reaching 1.333%, 8.331, and 1.616, respectively. For the interaction between the reaping fruit time and fruit part used, the treatment F30 exhibited the highest percentage of nitrogen and proteins, reaching 1.561% and 9.756%, respectively, compared to the binary interaction treatment E10, which recorded the lowest percentage value (1.357% and 8.481%, respectively), and the treatment C10 which gave the lowest phosphorus percentage of

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0.533%. However, the difference between the fruit age and the fruit part used was insignificant in the phosphorus and potassium percentages.

Results in Table 3c show that genotype G was superior in the phosphorus percentage, recording 0.669%, compared to the lowest phosphorus percentage recorded by genotype B, which was 0.571%. Genotype C produced the highest potassium percentage, reaching 2.116%, compared to genotype G, which recorded the lowest value, amounting to 0.645%. Regarding the fruit part used, treatment F was superior in the percentage of phosphorus and potassium, reaching 0.662 and 1.913%, respectively. The reaping fruit at age 30 days was the outperformed treatment, recording the highest percentage value of nitrogen, proteins, phosphorus, and potassium, reaching 1.520%, 9.500%, 0.667%, and 1.877%, respectively.

Table 3c. Effect of the genotypes, fruit part used, and fruit age on the percentage of nitrogen, protein, and phosphorus in the fruits

Genotype	N	P	K	protein
H	1.435	**0.659**	1.663	8.968
G	1.486	**0.669**	1.645	9.287
B	1.416	0.571	1.749	8.850
C	1.451	0.606	2.116	9.068
L.S.D (0.05)	N.S	0.017	0.051	N.S
Fruit part				
F	1.473	0.662	1.913	9.206
E	1.422	0.591	1.674	8.887
L.S.D (0.05)	N.S	0.004	0.028	N.S
Fruit age				
10	1.371	0.587	1.708	8.568
20	1.451	0.625	1.795	9.068
30	1.520	0.667	1.877	9.500
L.S.D (0.05)	0.03401	0.010	0.030	0.2126

Knowing that H, G, B, and C = genotypes, F = the fruit without seeds, E = the whole fruit, 10 = the fruit is ten days old, 20 = the fruit is 20 days old, and 30 = the fruit is thirty days old.

DISCUSSION

The appropriate time for harvesting medicinal plants must be decided so that the amount of medicinally active components is as high as possible, as they differ according to the difference in collection times (the fruit age) and even according to the genotypes. Climatic conditions, including temperature, light, relative humidity, and others, play an essential role in vegetative growth and the synthesis of the active components in plants, as they influence the biological processes in plants, including photosynthesis, respiration, and absorption of water and nutrients .

The reason that the interaction treatment, CF20, produced the highest Charanitin concentration and the two treatments, BE10 and CE10, produced the highest concentration of phenols and the interaction treatment, GE20, recorded the highest Momordin concentration, may be because the strains C and G are promising and powerful that can absorb nutrients, which was confirmed by that strain G was superior in its content of nitrogen, protein, and phosphorus, which reflected positively on their content of medicinal compounds, especially when the fruits reaped at age 20 days. Treatment E was superior in giving the highest concentration Charantin and treatment E was superior in giving the highest concentration Momordin and phenols, . Thus, the reason for the increase in charanitin and Momordin may be due to the genetic and environmental factors that affect the biosynthesis of active compounds in medicinal plants, as the concentration of these compounds is also affected by agricultural practices, including the reaping time (27). These factors also affect the chemical composition and storage sites of secondary compounds within medicinal plants. (15, 42, 11). These results are consistent with the findings of an experiment conducted by (4) on bitter gourd regarding the difference in the concentration of Charanitin in the fruits depending on the genotypes, fining of (8) on the beetroot plant, and the findings of (6) on the harvest date of celery, dandelion, and chamomile plants. These results are also consistent with results obtained by (23) on the saffron plant, (21) on zucchini and medicinal squash plants, and (55) on the strawberry plant, who found an effect of the interaction between the genotype and the harvest date on the content of ascorbic acid and total phenols in the fruits.

CONCLUSIONS

We conclude from the above that the bitter gourd fruits contain active substances whose concentration significantly increases and differs according to the genotype and the reaping fruit time, as reaping fruit at 20 days old is the best age to obtain the highest concentration of Charanitin and Momordin.

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