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Nutrient Status and Oil Yield of Grain *Amaranthus species*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Amaranth grain is an underutilized crop known for its vegetative parts as vegetable and grain as food. The grain of the crop contains high amount of iron, magnesium, calcium, potassium and other minerals. However, there are gaps in our understanding and technology on the nutritional diversity of different kinds of vegetables grown in India. The aim of this study was to analyse the nutritional value of amaranth grains from different genotypes (*A. hypochondriacus, A. cruentus, and A. caudatus*) and to select elite genotype for varietal development. Randomized block design with three replication was carried. Evaluation studies were carried out by planting different amaranthus genotypes in the orchard at Tamilnadu Agricultural University, Coimbatore in the year 2022-23. The nutrient composition of the grains was determined using standard methods. The genotype EC-198122 recorded highest nutritional quality followed by IC–37156. Among the thirty six genotypes EC- 198122 genotype were found to be rich in proteins (20.85%), fat (6.32%), carbohydrate (71.59%), fiber (5.65%), energy (426.64 Kcal), and sugar (1.12g). EC- 198122 genotype contain a

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high amount of iron (22.74 mg/100g), magnesium (157.3 mg/100g), calcium (199.67mg/100g), potassium (309.77 mg/100g) and other minerals. The anti-nutrients composition also found to be low in grains were oxalate (194mg/100g) and nitrate (87.34μg/g) which are within levels that can be tolerated by the body system. The genotype EC- 198122 (5.20%) posses high oil content. The oil extracted from amaranth grain contained mainly unsaturated fatty acids. The primary acids in the oil were oleic, linoleic and palmitic. Oil was a major component present in the grain amaranthus. This suggests that consuming amaranth grain could be an effective way for mitigating the macro- and micronutrient deficits in the diet.

Keywords: Grain Amaranthus; nutraceutical properties; oil content; antinutritional factors.

1. INTRODUCTION

Current epidemiological health scenario need nutrient enriched foods that are easily available worldwide and in India. Therefore, during the recent decades, a great deal of researchers has concentrated their attention to the valorization of important underutilized or forgotten crops to meet out nutritional security.

Amaranth is one of the multi-purpose crops that can provide grains and pleasant leafy vegetables of excellent nutritional content as food and animal feed, and it may also be grown as an ornamental plant due to its stunning inflorescence coloration [1]. Grain amaranthus, additionally referred to as "Rajgira" or "Ramadana," is a member of the family Amaranthaceae and sub-family Amaranthoideae of the genus. Amaranthus is consideredas a pseudocereals that resemble cereal grains. In the 1970s, American scientists began to investigate grain amaranth. There were a few thousand acres being farmed there by the end of the 1970s, and they are still farmed today. In a few places in Mexico, grain amaranth is also grown as a food crop. During festival season, it is used to manufacture a confectionery known as alegra. In various ways, the grain might be popped like popcorn and then combined with honey or eaten cold as a morning cereal with milk, almonds, and dried fruit. It consists of 60-70 species and it is short duration crop which was cultivated for both leaf and grain yield. The grains are rich source of oil content and it has many industrial uses. Major grain amaranth species are *A.hypochondriacus, A.creuntus, and A.caudatus.* Pseudocereal like amaranth, buck wheat, quinoa has been known as protein rich food and gluten free cereals. The protein, energy malnutrition and micronutrient deficiencies cause one-third of child fatalities in Africa and this can be mitigated by utilizing underutilized nutrient-dense crop species with African ancestry [1].

Amaranth grain contains about 15% of protein. Amaranth grain and leaves are an excellent source of high quality protein and lipids with higher contents of minerals, such as Ca, K and P than cereal grains [2,3]. Amaranth grains have a better nutritional value than rice and includes more than three times the average amount of calcium found in main cereals, as well as being high in iron, magnesium, phosphorus, and potassium. Starch is the main component of amaranth grain and has been used in healthy and organic food preparations. The starch granules makes it useful in industries-lubricants in the computer industry and cosmetics [4]

Amaranth oil is a powerful natural antioxidant supplement that can shield cellular membranes from oxidative damage and increases the content of polyunsaturated fatty acids in the diet. Squalene, an unsaturated triterpene hydrocarbon used in skin cosmetics and as a lubricant for computer disks, is abundant in the oil of amaranthus species. Naturally squalene is obtained from the liver of sea animals, but amaranthus is the only plant source to obtain squalene, and would reduce the risk of cancers [5]. Amaranth oil also has several health advantages, a high nutritional value, and industrial applications also. Amaranth oil helps the clinical manifestation of coronary heart disease and high blood pressure. The main objective of the present study was to evaluate the nutritional qualities of different genotypes and also to select elite genotypes of amaranth suitable for oil extraction.

2. MATERIALS AND METHODS

2.1 Research Design

The present investigation was carried out in the orchard of Department of Vegetable Science, Tamilnadu Agricultural University at Coimbatore. Thirty six genotypes of grain amaranth were evaluated in Randomized Block Design with three replications during 2022-23. Out of thirty six genotypes, 26 genotypes were collected from

NBPGR, Regional Station - Shimla and ten genotypes were collected from Centre of excellence in Millets located at Athiyandhal, Thiruvannamalai district of Tamilnadu in India. The field was ploughed thoroughly followed by harrowing and leveling was done. The genotypes were grown in a plot size 3x3 m keeping row to row and plant to plant spacing of 30x15 cm in each replication. Observations were recorded and mean data were analyzed on qualitative characters of protein content (%), carbohydrates (%), fibre, fat content (%), sugars (g), calcium(mg), magnesium(mg), potassium (mg),iron(mg), carotenoids ,vitamins and oil content (%). Profiling of the nutrients and anti-nutrient elements in grains and the mean values were used for statistical analysis. The gathered grains were dried and processed into powder form with the aid of a mixer to acquire samples for the proximate composition of mineral, and vitamin analysis. By appropriately quantifying the samples by using standard procedures [6] to analyse them for protein, fat, and carbohydrate content, the proximate composition became apparent. Protein was determined by Lowry's method. The Soxhlet method was used to determine fat content and Oil content [6] as hexane was used as solvent to extract the oil from the grain amaranths. The muslin cloth method was used to determine the crude fiber [6] Crude protein, carbohydrate, and fat percentages were multiplied by 4 and 9 to determine the amount of calories present in the sample however it was calculated by using formula, Energy (kcal/100) = [9 fat (%) + 4 carbohydrate (%) + 4 protein (%)]. The carbohydrates were determined by adding the percentage values of moisture, crude protein, ash, and crude fat and deducting the sum from 100 [7]. The calorimetric method was used to determine arytenoids content in the grain amaranthus. Sugar content was determined by Folins and WU method [8] and Ascorbic acid estimation was done by using the volumetric method [6]. Microelements like Calcium, Magnesium, Iron, and Potassium were analyzed by inductively coupled Plasma Mass Spectrometer couples (ICPMS) procedure Whereas High pure Millipore Water, Nitric acid, Hydrochloric acid were used for trace metal analysis. According to the modified titration method explained [9] the oxalate content was calculated.

2.2 Statistical Analysis

Two-way analysis of variance (two way ANOVA) tests were used to statistically analyse the data collected from each sample and Duncan's new Multiple Range test at 5% was used to evaluate the mean difference). This was done in order to compare the nutritional contents of the different genotypes.

3. RESULTS AND DISCUSSION

3.1 Nutrient Composition of Amaranth Grains

Different nutritional parameters were analysed in the grain amaranthus such as protein, carbohydrates, fibre, fat, vitamins, minerals and antinutritional characters viz., oxalate and nitrate. Protein content was highest in the genotype of EC-198122 (20.85%) followed by EC-359417(19.50%), IC-38120 (18.76%) and IC-37156 (18.50%). Grain amaranthus contain higher protein than other cereal grains [10,11] Carotenoid content was high in IC-37156 (10.97%) followed by EC-1918122 (10.89%), EC-359417-1(8.98%), IC-396963 (8.85%). Fibre content was high in EC-1918122(5.65%) followed by IC- 37156 (5.00 %), EC-359425 (4.95%), EC-359417-2 (4.90%). Total carbohydrate content were generally found to be high in the genotypes of EC-1918122 (71.59%) which was statistically on par with IC-37156(70.95%), EC-359417-1(70.80%) and EC-359440 (70.18%). Grain amaranthus contains high carbohydrates and carotenoids reported in some studies [12,13]. The desired level of energy can be obtained from the grain amaranthus, which ranged from 426.64 kcal to311.95 kcal. Among the genotypes, fat content was high in EC-359421(7.68%) followed by EC-359417-2(7.02%), IC- 21802A (6.99%) and lowest fat content was recorded in EC-359425(5.90%). Generally amaranthus grain contains a moderate range of fat that was accepted level to our body system. Fat content in the grain amaranth is two to three times higher than other cereals [14]. The sugar content was found to be lowest in the genotype of IC-568189 (0.78g) followed by IC-21802A (0.87g), GA-02 (0.88g), EC-359421 (0.90g) Sugar content was significantly low in the grains and it was considered as gluten free. So, amaranthus grains are recommended for diabetic patients and also useful to make baby foods. The results showed that grains of amaranthus genotypes were significantly high in protein, carbohydrates, fats, fibre, carotenoids particularly in the genotype of EC-198122 followed by IC-37156 and EC- 359440 as shown in Table 1. Nutrient composition was expressed in the Fig. 4.

Table 1. Nutrient composition of the grain amaranth of different genotypes

S. No.	Genotypes	Protein (%)	Carotenoid (mg)	Carbohydrates (%)	Crude fibre (%)	Energy (kcal)	Fat (%)	Sugar (g)	Oil content (%)
1	EC- 519520	13.12^{r}	4.59^{q}	61.45^{klmno}	3.24^{o}	355.00^{mno}	6.30^{ijklmno}	1.01^{kl}	4.00^{abcd}
2	EC- 519521	14.05^{opq}	7.32^{i}	63.95^{fghijkl}	4.19^{fg}	370.50^{hijklmn}	6.50^{gfijk}	1.31^{fg}	3.72^{abcd}
3	EC- 258252	13.78^{qr}	5.74^{o}	64.48^{efghij}	2.81^{p}	372.80^{ghijklm}	6.64^{efgh}	1.42^{e}	3.80^{abcd}
4	EC-359418	14.95^{mn}	5.15^{p}	65.74^{hijklm}	3.75^{lm}	378.83^{efghijk}	6.23^{jklmno}	1.33^{fg}	3.97^{abcd}
5	EC- 359425	15.50^{klm}	5.84^{no}	62.91^{hijklm}	4.95^{bc}	366.74^{ijklmn}	5.90^{pqr}	1.62^{ab}	4.01^{abcd}
6	EC- 198122	20.85^{a}	10.89^{a}	71.59^{a}	5.65^{a}	426.64^{a}	6.32^{ijklmn}	1.12^{ij}	5.20^{a}
7	EC- 359417	19.50^{b}	8.11^{ef}	63.80^{fghijkl}	3.64^{mn}	384.00^{defghi}	5.65^{r}	1.50^{d}	3.14^{bcd}
8	EC- 359417-1	16.32g^{hij}	8.98^{b}	70.80^{ab}	3.78^{klm}	402.40^{bcd}	6.00^{opq}	1.41^{e}	3.36^{bcd}
9	EC- 359417 -2	16.75^{fghi}	7.98^{fg}	62.35^{ijklmn}	4.90^{bc}	379.40^{efghijk}	7.02^{b}	1.32^{fg}	3.24^{bcd}
10	EC- 359440	17.87^{de}	8.35^{de}	70.18^{abc}	4.86^{bc}	403.76^{bc}	5.76^{qr}	1.50^{d}	4.20^{abcd}
11	EC- 359421	16.61^{fghi}	6.85^{jk}	69.95^{abc}	4.54^{e}	415.36^{ab}	7.68^{a}	0.90^{l}	4.00^{abcd}
12	IC- 35363	17.01^{fg}	5.18^{p}	68.16^{bcd}	3.81^{klm}	395.76^{cde}	6.12^{mnop}	1.01^{kl}	3.00^{bcd}
13	IC- 35366	18.64^{c}	6.79^{k}	64.47^{efghij}	3.92^{jkl}	390.40^{cdefg}	6.45^{ghijk}	1.04^{k}	3.43^{bcd}
14	IC- 35367	18.19^{cd}	6.45^{lm}	63.10^{ghijklm}	4.88b^{c}	387.50d^{efghi}	6.98^{bc}	1.34^{f}	3.26^{bcd}
15	IC - 37156	18.50^{cd}	10.97^{a}	70.95^{a}	5.00^{b}	413.60^{ab}	6.21^{klmno}	1.22^{h}	4.42^{ab}
16	IC- 38120	18.76^{c}	6.15^{mn}	62.00^{ijklmn}	3.71^{m}	379.90^{efghijk}	6.32^{ijklmn}	1.40^{e}	2.99^{bcd}
17	IC -38378	17.81^{de}	7.67^{gh}	63.38^{fghijklm}	3.64^{mn}	383.62^{defghij}	6.54^{fghij}	1.55^{c}	2.64^{d}
18	IC-258250	15.97^{hijkl}	7.96^{fg}	64.17^{efghijkl}	4.31^{f}	374.65^{fghijkl}	6.01^{opq}	1.47^{d}	3.00^{bcd}
19	IC- 313273	16.25^{ghijk}	8.13^{ef}	63.98^{fghijkl}	4.19^{fg}	378.34^{efghijk}	6.38^{hijklm}	1.32^{fg}	3.14^{bcd}
20	IC- 341551	16.47^{fghij}	8.56^{cd}	65.93^{defg}	3.48^{n}	387.65^{cdefgh}	6.45^{ghijk}	1.11^{ij}	3.32^{bcd}
21	IC- 396963	16.00^{hijkl}	8.85^{bc}	68.15^{bcd}	3.63^{mn}	390.60^{cdefg}	6.00^{opq}	1.09^{j}	5.07^{a}
22	IC-540860	16.45^{fghij}	7.96^{fg}	59.48^{nopq}	4.78^{cd}	361.93^{klmn}	6.49^{ghijk}	1.15^{i}	3.71^{abcd}
23	IC- 568189	17.21^{ef}	8.61^{cd}	66.13^{def}	4.56^{e}	390.51^{cdefg}	6.35^{hijklm}	0.78^{n}	4.10^{abcd}
24	IC- 582977	18.23^{cd}	6.85^{jk}	64.91^{efghi}	3.81^{klm}	392.86^{cdef}	6.70^{cdefg}	1.28^{g}	4.37^{abc}
25	EC- 289385	15.77^{jkl}	7.77^{fgh}	64.32^{efghijk}	3.63^{mn}	382.82^{efghij}	6.94^{bcd}	1.32^{fg}	3.21^{bcd}
26	EC- 519515	15.89^{ijkl}	7.81^{fg}	67.81^{cd}	3.49^{n}	393.84^{cdef}	6.56^{efghi}	1.41^{e}	3.44^{bcd}
27	IC- 21790	14.85^{mn}	6.59^{kl}	67.88^{cd}	4.12^{gh}	392.20^{cdef}	6.81^{bcdef}	1.35^{f}	2.91^{bcd}
28	Sitheri local	14.75^{mno}	6.82^{jk}	61.50^{jklmno}	4.65^{de}	362.87^{klmn}	6.43^{ghijkl}	0.98^{l}	4.30^{abc}
29	IC- 32191	15.32^{lmn}	7.15^{ij}	67.00^{de}	4.00^{hij}	390.93^{cdefg}	6.85^{bcde}	1.59^{bc}	2.60^{d}
30	IC- 21802A	17.01^{fg}	8.08^{ef}	61.25^{lmno}	3.81^{klm}	311.95^{p}	6.99^{bc}	0.87^{m}	3.99^{abcd}
31	BGA- 4-9	16.65^{fghi}	6.88^{jk}	58.97^{opq}	2.76^{p}	356.66^{lmn}	6.02^{nopq}	1.14^{i}	3.09^{bcd}

S. No.	Genotypes	Protein (%)	Carotenoid (mg)	Carbohydrates (%)	Crude fibre (%)	Energy (kcal)	Fat (%)	Sugar (g)	Oil content (%)
32	GA-02	14.00^{pq}	4.00^{r}	60.00^{nop}	3.91^{jkl}	353.60^{no}	6.40^{ghijklm}	0.88^{m}	2.74^{cd}
33	IC- 5994	16.18^{hijk}	6.19^{m}	58.00^{pq}	2.81^{p}	356.57^{lmn}	6.65^{defgh}	1.00^{kl}	3.43^{bcd}
34	IC- 32336	12.00^{s}	7.45^{hi}	56.81^{q}	2.58^{q}	338.33^{o}	7.01^{b}	0.70^{0}	3.70^{bcd}
35	Thirupathur local	14.61^{nop}	6.14^{mn}	60.50^{mnop}	3.26^{o}	355.70^{mno}	6.14^{lmnop}	1.64^{a}	3.90^{abcd}
36	IC- 32197	13.96^{pq}	7.89^{fg}	61.88^{jklmn}	3.94^{ijk}	364.56^{klmn}	6.80b^{cdef}	1.57^{c}	4.00^{abcd}
Maximum		20.85	10.97	71.59	5.65	426.64	7.68	1.64	5.20
Minimum		12.00	4.00	56.81	2.58	311.95	5.65	0.70	2.60
Mean		16.27	7.30	64.39	3.97	378.97	6.46	1.24	3.62
S.EM		0.24	0.11	0.88	0.05	5.69	0.09	0.02	0.47
SE.d		0.35	0.16	1.25	0.08	8.05	0.13	0.02	0.67
CV		2.60	2.61	2.37	2.40	2.60	2.46	2.24	22.53
CD (5%)		0.69	0.31	2.48	0.16	16.06	0.26	0.05	1.33
Range		67.78	67.81	20.57	170.46	1.02	10.76	41.50	2.60

Table 2. Mineral composition and antinutritional content of the grain amaranth genotypes

S.NO	Genotypes	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Potassium (mg/100g)	Vit - C (mg/100g)	Nitrate µg/g)	Oxalate (mg/100g)
1	EC- 519520	183.75^{e}	154.83^{ghi}	9.11^{ef}	310.75^{ef}	4.20^{hijklmn}	93.45a^{b}	79.95^{cdefg}
2	EC- 519521	185.54^{cde}	155.32^{fghi}	9.32^{e}	311.84^{ef}	4.01^{mn}	93.69^{ab}	78.68^{efg}
3	EC- 258252	189.09^{bcde}	158.19^{defgh}	10.43^{d}	319.24^{de}	4.33^{ghij}	93.87^{ab}	82.00^{cdef}
4	EC-359418	193.81^{abcde}	151.36^{hi}	10.56^{d}	325.19^{de}	4.69^{bcde}	94.81^{ab}	78.15^{fg}
5	EC- 359425	194.11^{abcd}	160.78^{defg}	10.21^{d}	312.46^{e}f	4.73^{bcde}	94.64^{ab}	112.00^{b}
6	EC- 198122	199.67^{a}	157.3^{efghi}	22.74^{a}	309.77^{e}f	4.88^{ab}	87.34^{f}	77.90^{fg}
7	EC- 359417	196.58^{ab}	163.25^{cdefg}	8.32^{h}	314.60^{e}	4.59^{def}	92.98^{bcd}	79.32^{efg}
8	EC-359417-1	193.49^{abcde}	164.74^{cde}	8.91^{f}	312.70^{ef}	4.39^{fgh}	93.14^{abcd}	80.01^{cdef}
9	EC- 359417-2	194.76^{abcd}	169.52^{bc}	8.49^{gh}	313.49^{ef}	4.33^{ghij}	88.68^{cdef}	113.21^{b}
10	EC- 359440	197.63^{ab}	186.63^{a}	13.76^{b}	314.60^{e}	5.00^{a}	92.44^{bcde}	78.25^{fg}
11	EC- 359421	194.01^{abcd}	163.11^{cdefg}	7.37^{ijk}	312.54^{ef}	4.09^{klmn}	94.29^{ab}	82.56^{cde}
12	IC- 35363	194.27^{abcd}	165.81^{cd}	7.68^{i}	311.28^{ef}	4.78^{abcd}	88.50^{def}	78.49^{cdefg}
13	IC- 35366	196.89^{ab}	150.98^{hi}	8.79^{fg}	310.09^{ef}	4.69^{bcde}	95.48^{ab}	78.53^{efg}
14	IC- 35367	184.41^{de}	156.47^{efghi}	6.34^{m}	314.25^{ef}	4.81^{abcd}	95.39^{ab}	81.01^{cdef}

S.NO	Genotypes	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Potassium (mg/100g)	Vit - C (mg/100g)	Nitrate µg/g)	Oxalate (mg/100g)
15	IC – 37156	197.24^{ab}	190.70^{a}	9.38^{e}	315.78^{e}	4.85^{abc}	88.31^{ef}	79.00^{efg}
16	IC- 38120	196.12^{ab}	158.54^{defgh}	8.15^{h}	310.32^{ef}	4.38^{fgh}	94.62^{ab}	82.53^{cde}
17	IC -38378	194.45^{abcd}	162.14^{cdefg}	6.32^{m}	321.41^{de}	4.13^{ijklm}	93.71^{ab}	81.99^{cdef}
18	IC-258250	195.18^{abc}	151.32^{hi}	7.00^{kl}	320.97^{de}	4.51^{efg}	93.00^{bcd}	82.00^{cdef}
19	IC- 313273	190.38^{abcde}	149.21^{ij}	6.21^{m}	322.35^{de}	4.82^{abcd}	94.93^{ab}	79.32^{efg}
20	IC- 341551	197.63^{ab}	158.54^{defgh}	6.98^{l}	439.60^{a}	4.66^{bcde}	94.51^{ab}	79.57^{defg}
21	IC- 396963	188.34^{bcde}	188.34^{a}	9.01^{ef}	321.47^{de}	4.73^{bcde}	93.78^{ab}	79.21^{efg}
22	IC-540860	187.10^{bcde}	187.10^{a}	7.43^{ij}	323.68^{de}	4.64^{cde}	92.60^{ab}	78.37^{efg}
23	IC- 568189	190.00^{abcde}	190.00^{a}	7.18^{jkl}	320.19^{de}	4.35^{ghi}	93.18^{ab}	78.45^{efg}
24	IC- 582977	194.11^{abcd}	194.11^{a}	8.43^{gh}	312.66^{ef}	4.14^{ijklmn}	93.54^{ab}	79.00^{efg}
25	EC- 289385	193.25^{abcde}	164.32^{cde}	5.32^{n}	315.00^{e}	4.28^{ghijkl}	94.60^{ab}	82.14^{cdef}
26	EC- 519515	196.29^{ab}	163.19^{cdefg}	5.01^{no}	340.37^{c}	4.19^{hijklmn}	94.32^{ab}	83.88^{c}
27	IC- 21790	196.53^{ab}	164.56^{cde}	5.24^{n}	331.49^{cd}	4.20^{hijklmn}	95.00^{ab}	83.54^{cd}
28	Sitheri local	194.48^{abcd}	173.86^{b}	6.21^{m}	313.09^{e}f	4.24^{hijklm}	95.38^{ab}	80.78^{cdef}
29	IC- 32191	193.00^{abcde}	162.14^{cdefg}	5.18^{n}	315.58^{e}	4.27^{hijkl}	95.73^{ab}	79.85^{cdefg}
30	IC- 21802A	195.42^{abc}	163.48^{cde}f	4.54^{p}	342.00^{c}	4.29^{ghijk}	96.00^{ab}	79.64^{defg}
31	BGA- 4-9	196.86^{ab}	170.00^{bc}	4.96^{no}	280.59^{hi}	4.59^{def}	93.25^{abc}	80.64^{cdefg}
32	GA-02	196.43^{ab}	151.08^{hi}	4.73^{op}	287.35^{gh}	4.64^{cde}	95.61^{ab}	78.09^{fg}
33	IC- 5994	195.32^{abc}	149.32^{ij}	2.65^{q}	294.32^{g}	4.05^{lmn}	94.75^{ab}	83.94^{c}
34	IC- 32336	131.89^{f}	126.30^{k}	13.14^{c}	269.14^{i}	3.98^{n}	96.00^{ab}	80.00^{cdefg}
35	Thirupathur local	192.18^{abcde}	152.07^{hi}	2.17^{r}	388.36^{b}	4.11^{jklmn}	96.08^{ab}	76.50^{g}
36	IC- 32197	196.84^{ab}	142.83^{j}	5.27^{n}	299.00^{fg}	4.32^{ghijk}	98.10^{a}	118.00^{a}
Maximum		199.67	194.11	22.74	439.60	5.00	98.10	118.00
Minimum		131.89	126.30	2.17	269.14	3.98	87.34	76.50
Mean		191.86	163.10	7.85	318.82	4.44	93.77	82.96
S.EM		3.01	4.45	0.13	4.52	0.07	1.43	1.21
SE.d		4.25	6.29	0.18	6.40	0.10	2.03	1.71
CV		2.71	4.72	2.80	2.46	2.74	2.65	2.53
CD (5%)		8.48	12.54	0.36	12.76	0.20	4.04	3.53
Range		67.78	67.81	20.57	170.46	1.02	10.76	41.50

3.2 Mineral Composition of the Grain *Amaranthus*

The results of mineral content in the grain amaranth was generally high when compared with other cereals [2]. The value of mineral contents was expressed in mg/100g of sample. The results showed that calcium content was high in the genotype of EC-198122 (199.67mg/100g) followed by EC- 359440 (197.63mg/100g), IC- 341551(197.63 mg/100g), IC- 37156 (197.24 mg/100g), and IC-IC-35366. Magnesium was found to be high in IC- 582977 (194.11mg/100g) followed by IC- 37156 (190.70mg/100g), IC- 568189 (190mg/100g), IC-396963 (188.34mg/100g,), IC-540860 (187.1 mg/100g), EC- 359440 (186.63mg/100g. Iron content was high in the genotype of EC-198122 (22.74 mg/100g) followed by IC-37156 (13.76mg/100g), EC- 359418 (10.56mg/100g), EC-258252 (10.43mg/100g), -359425(10.21 mg/100g), IC- 37156(9.38mg/100g). Potassium was generally high in all genotypes but IC-341551 possess very high in the range of (439.60 mg/100g) followed by IC- 21802A (342mg/100g), EC-519515(340mg/100g), IC-21790(331.49mg/100g), IC-540860 (mg/100g). Vitamin-C content was high in EC-198122(4.88mg/100g) followed by IC-313273(4.82mg/100g), IC- 35367(4.81mg/100g), and IC-35363(4.78mg/100g). Therefore result demonstrated that amaranthus had high levels of different minerals components in the grains [15]. The mineral composition are shown in the Figs. 1 and 2.

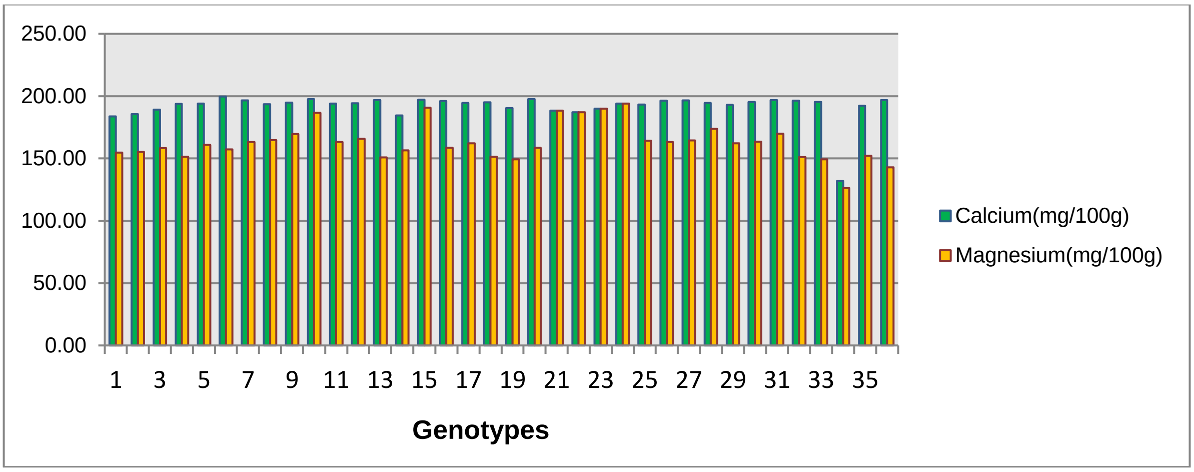

Fig. 1. Mineral composition of grain amaranthus

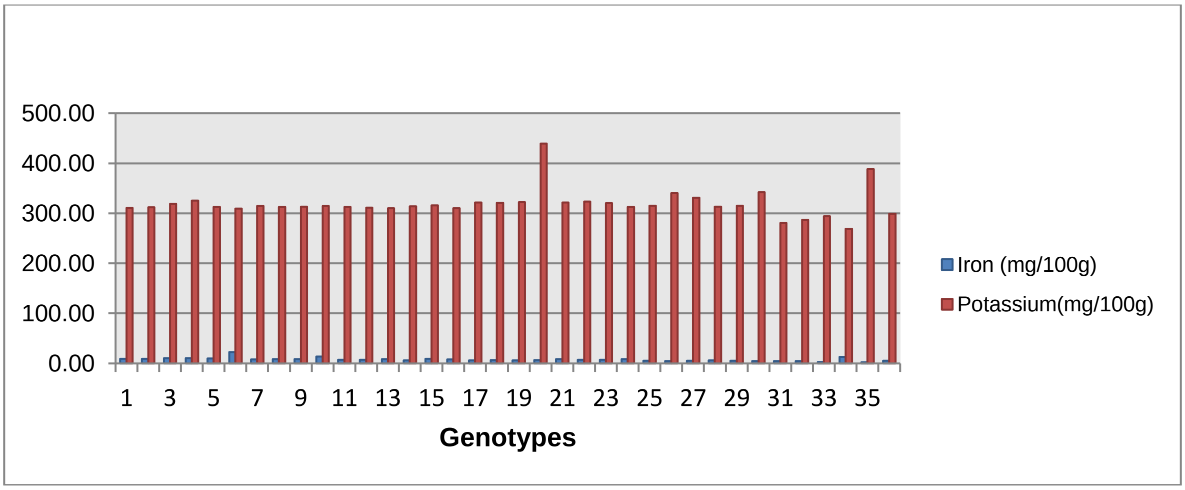

Fig. 2. Mineral composition of grain amaranthus

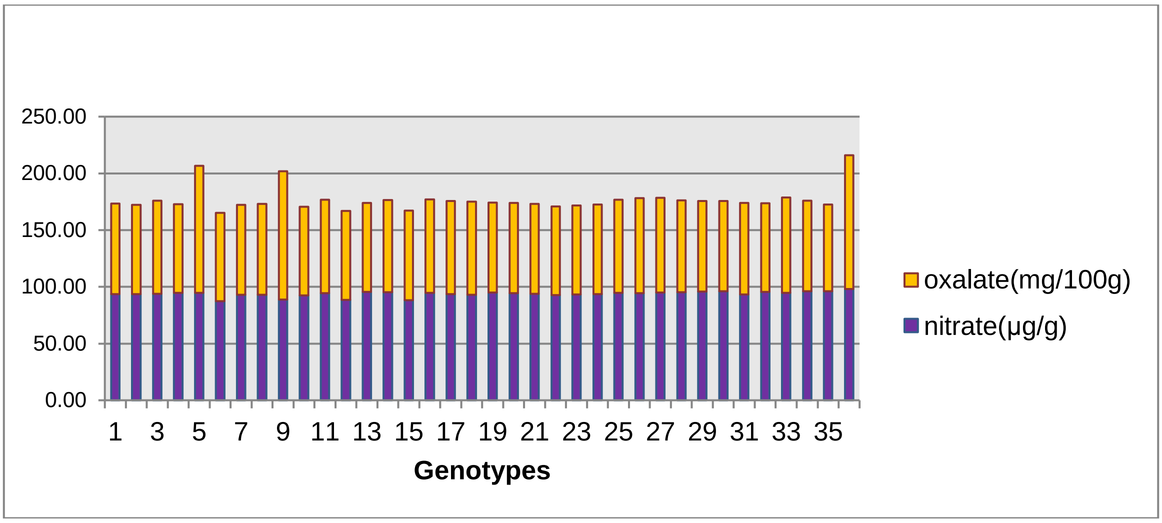

Fig. 3. Antinutrient factors of grain amaranthus

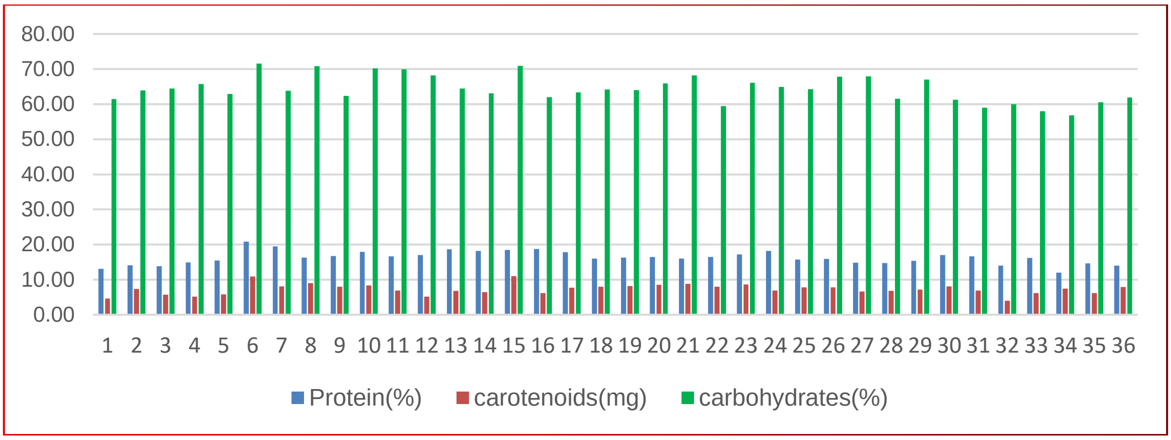

Fig. 4. Nutrient composition of grain amaranthus

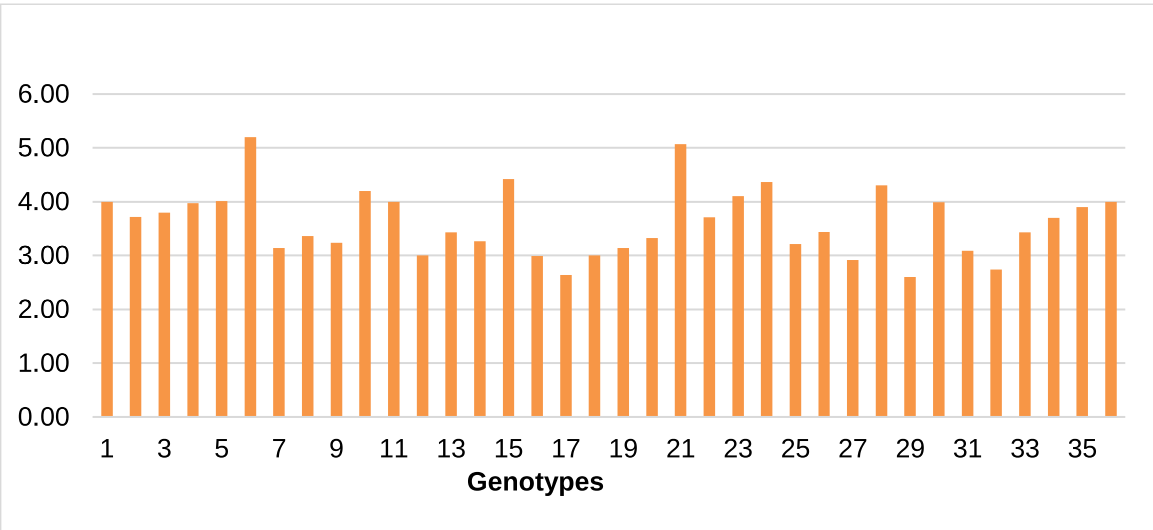

Fig. 5. Oil content (%) in grain amaranthus

3.3 Antinutrients Composition of Grain *Amaranthus*

The results of the antinutrients content in the grains are presented in the Table 2. Among the genotypes, Thirupathur local type recorded significantly lowest oxalate content (76.50 mg/100g) followed by EC-198122 (77.90 mg/100g), GA-02(78.09 mg/100g), and EC-359418 (78.15mg/100g), EC- 359440 (78.25mg/100g). Amaranth leaves posses significantly high amount of oxalate compared with grains [16,17]. Oxalate content in grain amaranth show a significant difference in their levels. Nitrate content in EC-198122 (87.34µg/g) was significantly low which was followed by IC-37156(88.31µg/g), IC- 35363(88.50µg/g) and EC- 359417-2 (88.68µg/g). Nitrate content present in the grain amaranth ranged from 98.10 to 87.34µg/g. Generally nitrate concentration declined with plant maturity. The amount of nitrate content in plants is governed primarily by its genetically based metabolism, age of the plant, environmental conditions, and the amount of accessible nitrate in the soil [18,19]. The nitrate concentration of *A. cruentus species* dropped with plant age, supporting the finding that the nitrate content reduced with maturity [20,21]. The least effective approach for lowering anti-nutrient content was found to be roasting of grains [5]. Amaranth grain was roasted, which reduced the oxalate by 56.1%. To reduce the antinutrients, content grains were boiled and popped about 80.9% of the total oxalate were lost [22]. It is well known that grain amaranth can improve its nutritional value and reduce these anti-nutrient elements by undergoing thermal processing. The influence of temperature-time combinations on the lowering of anti-nutrient components is one of the many and diverse factors that affect these processes [5]. Cooking food in water is one way to get oxalate and tannin out of it, but it's not the best solution. In comparison to only wet cooking, soaking followed by wet cooking may eliminate oxalate more quickly [23]. Antinutrient composition was shown in the Fig. 3.

4. OIL CONTENT

From the present study, it was observed that percentage of the oil content was significantly high in the genotype of EC-198122(5.20%) followed by IC-396963(5.07%), IC-37156(4.42%), IC- 582977 (4.37%). Other genotypes posses the oil content ranged from 2.64% to 4.00 %. The oil extracted from amaranth grain contains mainly unsaturated fatty acids [24,25]. The most often used organic solvent in the oil seed extraction operation was hexane which is effective at recovering oil, affordable, able to be recycled non-polar solvent, has a low heat of vaporisation, and a low boiling point (63-67◦C). Amaranth grain oil can be extracted by different methods viz., Soxhlet, supercritical fluid and accelerated solvent extraction. Among the three methods the highest yield of oil in the grain was obtained by accelerated solvent extraction followed by soxhlet method [26,27]. Therefore, amaranth grain oil can be recommended as a functional food source for the management of cardiovascular disorders and also rich in nutrients [25,5]. Oil composition was shown in the Fig. 5.

5. CONCLUSION

The grain amaranth genotypes EC-198122, IC-37156, EC- 359440, IC- 582977, IC- 341551 have been identified as nutrient rich genotypes with low antinutritional factors. EC-198122, IC-396963, IC- 37156, EC- 359440, IC- 568189 and have been identified as high oil yielding genotypes. Among all the genotypes EC-198122, IC- 37156, EC- 359440 were recorded as elite genotype for nutritional qualities and high oil yielding. It is concluded from the study that amaranthus grain, a gluten free pseudo cereal contains all the essential macro and micro nutrients. Because of its remarkable nutritional and physiological characteristics, grain amaranthus ssp. has been gaining widespread attention. Amaranth leaves and grains are highly nutritionally rich in carbohydrates, magnesium, potassium,fibre, protein, vitamin C, iron, carotenoids, calcium. Grains are rich nutrient source food item which helps to mitigate malnutrition and enhancing nutritional security. Grains are also suitable to produce the value added products without losing the nutritional properties.Among the three grain amaranthus species *(A.hypochondriacus, A.creuntus, A.caudatus)* evaluated A.creuntus possess high nutrient and high oil content.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Aderibigbe OR, Ezekiel OO, Owolade SO, Korese JK, Sturm B, Hensel O. Exploring the potentials of underutilized grain amaranth (*Amaranthus spp*.) along the value chain for food and nutrition security: A review. Critical Reviews in Food Science and Nutrition. 2022;62(3):656-69.
2. Alegbejo JO. Nutritional value and utilization of Amaranthus (Amaranthus spp.)–a review. Bayero Journal of Pure and Applied Sciences. 2013;6(1):136-43.
3. de la Barca AM, Rojas-Martínez ME, Islas-Rubio AR, Cabrera-Chávez F. Gluten-free breads and cookies of raw and popped amaranth flours with attractive technological and nutritional qualities. Plant Foods for Human Nutrition. 2010; 65:241-6.
4. Grubben GJ, Denton OA. Plant resources of tropical Africa 2. Vegetables. Plant resources of tropical Africa 2. Vegetables; 2004.
5. Makobo ND, Shoko MD, Mtaita TA. Nutrient content of Amaranth (*Amaranthus cruentus* L.) under different processing and preservation methods. World journal of Agricultural sciences. 2010;6(6):639-43.
6. AOAC A. Official methods of analysis 16th Ed. Association of official analytical chemists. Washington DC, USA. Sci. Educ; 1995.
7. Hussein SA, Shahin MF, Masoud MR. Effect of using lemongrass and thyme on some beefburger characteristics. Egyptian Journal of Agricultural Research. 2015; 93(1):133-45.
8. Feng X, Pan L, Wang Q, Liao Z, Wang X, Zhang X, Guo W, Hu E, Li J, Xu J, Wu F. Nutritional and physicochemical characteristics of purple sweet corn juice before and after boiling. PLoS One. 2020;15(5):e0233094.
9. Unuofin JO, Otunola GA, Afolayan AJ. Nutritional evaluation of *Kedrostis africana* (L.) Cogn: An edible wild plant of South Africa. Asian Pacific Journal of Tropical Biomedicine. 2017;7(5):443-9.
10. Akin-Idowu PE, Odunola OA, Gbadegesin MA, Oke A, Orkpeh U. Assessment of the protein quality of twentynine grain amaranth (*Amaranthus spp.* L.) accessions using amino acid analysis and one-dimensional electrophoresis. African Journal of Biotechnology. 2013;12(15).
11. Rastogi A, Shukla S. Amaranth: A new millennium crop of nutraceutical values. Critical Reviews in Food Science and Nutrition. 2013;53(2):109-25.
12. Kariuki SW, Sila DN, Kenji G. Nutritional profile of amaranth grain varieties grown in Kenya. Journal of Agriculture and Food Technology. 2013;17:19-25.
13. Maurya NK, Arya P. Amaranthus grain nutritional benefits: A review. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):2258-62.
14. León-Camacho M, García-González DL, Aparicio R. A detailed and comprehensive study of amaranth (*Amaranthus cruentus* L.) oil fatty profile. European Food Research and Technology. 2001;213:349-55.
15. Makobo ND, Shoko MD, Mtaita TA. Nutrient content of Amaranth (*Amaranthus cruentus* L.) under different processing and preservation methods. World journal of Agricultural sciences. 2010;6(6):639-43.
16. Amanabo M, Ogbadoyi EO, Johnson AO, Mathew IS, Akanya HO. Effect of heading on some micronutrients, anti-nutrients and toxic substances in *Amaranthus cruentus* grown in Mnna, Niger State, Nigeria.
17. Nicodemas D. Nutrient and anti-nutrient contents of selected varieties of grain and leafy amaranths in Tanzania (Doctoral dissertation, Sokoine University of Agriculture).
18. Singh A, Punia D. Characterization and nutritive values of amaranth seeds. Current Journal of Applied Science and Technology. 2020;39(3):27-33.
19. Umar KJ, Hassan LG, Dangoggo SM, Maigandi SA, Sani NA. Nutritional and anti-nutritional profile of spiny amaranth (*Amaranthus viridis* Linn). Studia Universitatis Vasile Goldis Seria Stiintele Vietii (Life Sciences Series). 2011;21(4).
20. Anuja S. Germplasm evaluation for quality attributes in amaranthus (*Amaranthus spp*.). Advances in Plant Sciences. 2012;25(2):443-7.

21. Kundub P, Sethia N, Guptab P, Bhattic JS. Evaluation of phytochemicals and anti-nutritional profile in underutilised green leafy vegetables. European Journal of Molecular & Clinical Medicine. 2021; 8(2):443-55.
22. Njoki JW, Sila DN, Onyango AN. Impact of processing techniques on nutrient and anti-nutrient content of grain amaranth (*A. albus*). Food Science and Quality Management. 2014;25:10-7.
23. Hotz C, Gibson RS. Assessment of home-based processing methods to reduce the phytate content and phytate/zinc molar ratio of white maize (*Zea mays*). Journal of Agricultural and Food Chemistry. 2001; 49(2):692-8.
24. Kumar SJ, Prasad SR, Banerjee R, Agarwal DK, Kulkarni KS, Ramesh KV. Green solvents and technologies for oil extraction from oilseeds. Chemistry Central Journal. 2017;11:1-7.
25. Prakash D, Joshi BD, Pal M. Vitamin C in leaves and seed oil composition of the Amaranthus species. International Journal of Food Sciences and Nutrition. 1995; 46(1):47-51.
26. Krulj J, Brlek T, Pezo L, Brkljača J, Popović S, Zeković Z, Bodroža Solarov M. Extraction methods of Amaranthus sp. grain oil isolation. Journal of the Science of Food and Agriculture. 2016;96(10): 3552-8.
27. Kaur S, Singh N, Rana JC. Amaranthus hypochondriacus and *Amaranthus caudatus* germplasm: Characteristics of plants, grain and flours. Food chemistry. 2010;123(4):1227-34.

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